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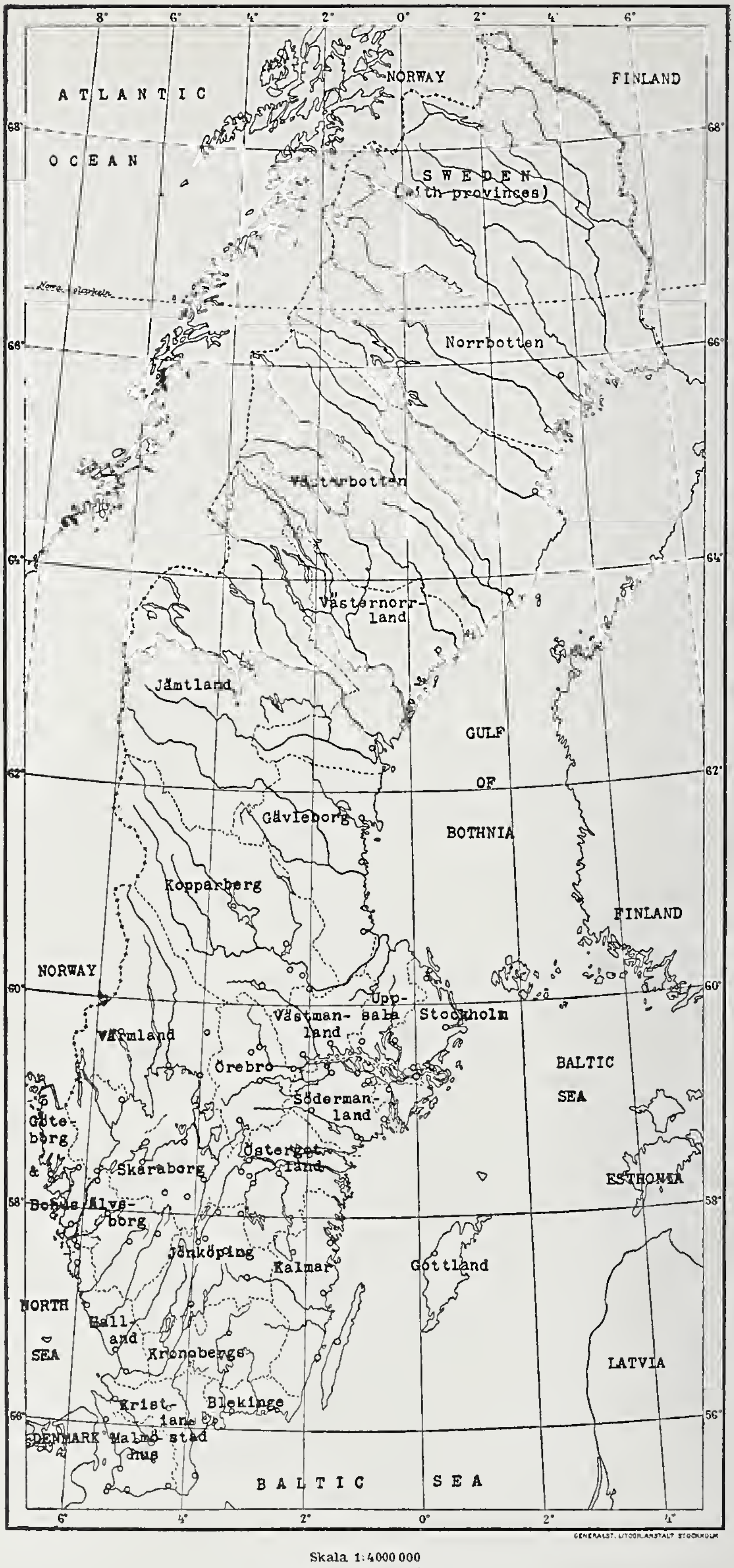

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FORESTRY IN SWEDEN
AND
ADJACENT LANDS
FROM
The Viewpoint of an American Forester

BY

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FOREWORD

THIS book is respectfully dedicated to the profession of forestry in America. It is hoped that some things may be herein contained that will start arguments, suggest research and stimulate activity. There are certainly great latent forestry opportunities in the New World. By comparison, possibilities in the U. S. A. surpass those found in Scandinavia from almost every standpoint. The future is bright in the East. If foresters can for awhile use the light of the experience of others, to keep their feet on higher ground and avoid the bogs that beset the way, they will soon see the dawn of the forestry day in America.

The author is "debtor to both Greeks and Barbarians; to both the wise and unwise" in collection of the facts that have been compiled into this work. Some misunderstandings and errors may be included. This is in part due to an imperfect mastery of the languages where verbal information has been worked up from notes; altho so far as was possible, statements have been checked against published material and references are frequently cited. To avoid repetition, references are made by use of bracketed numbers separated by dashes. The first number, as well as any that follow the word *and* or a comma (& or,), refer to the corresponding authority listed in the bibliography at the rear of the book. The last number, where more than one occurs not separated by *and* or a comma, always indicates the page of the cited work. Where reference is made to a periodical, there may be an intermediate number or numbers that give the date of the issue in which the citation occurs. As an example,—[12–2/1924–4] means that the cited facts are detailed on page 4 of the publication listed in the bibliography after the number *12,* and that it was published under date of February, 1924. In one instance where almost an entire chapter is based on a single reference source, this is set down under the chapter title and is thereafter cited by use of the abbreviation *Ref.* instead of a number.

In the interest of brevity, abbreviations have been used to an undesirable extent. These are in general such as are more or less standard in business English usage, but a few, *e. g.*—D.B.H. meaning *diameter* of a tree at *breast height* (4½ ft. above the ground) and N.S.R. for *reproduction* of the forest by *natural seeding,* are rather strictly limited to technical forestry.

While it is the aim in the pages that follow to give a comprehensive picture of forestry and allied activities of man in Sweden and Scandinavia in general, yet silviculture and forest management are most heavily emphasized. Utilization and lumber merchandising are treated quite cursively and incidentally because of the excellent way these phases of forestry have been described and analyzed by Axel H. Oxholm in U. S. Dept. of Commerce publications dealing with Sweden, Norway and Finland.

With three exceptions, the photographs used to illustrate the text are from the files of the Swedish State Forest Research Station at Stockholm.

The author acknowledges a heavy debt of gratitude to the American-Scandinavian Foundation and Mr. J. Hilmer Lundbeck, of New York City, who donated to that organization of international goodwill the fellowship that made this effort possible. Other fellows of this Foundation and its guiding spirits have encouraged this undertaking, and helped to quiet somewhat the misgivings with which it is thrust upon a "hardboiled" forestry world. Cordial thanks are extended to many friends and comrades in Scandinavia. Their kindness and hospitality cannot be repaid but shall never be forgotten. To superiors and associates in the Penna. Dept. of Forests and Waters and at the State Forest School, as well as numerous students there, the author offers earnest and sincere thanks in appreciation of interest, encouragement and direct or indirect assistance.

GEO. S. PERRY.

Penna. State Forest School,
Mont Alto, Pa.—June, 1929.

CHAPTER I

INTRODUCTION

SWEDEN has been a land of forests since the earliest times and continues today to occupy a commanding position among the countries of the earth as a wood-producer and lumber-exporter. [45 & 26] It is encouraging to foresters and economists when they note the present increasing productivity of forest areas, that furnished the wood to equip the ancestors of William the Conqueror with the ships that bore them on marauding expeditions to the ends of the known world. That these areas are more productive now than ever before is in general true, except for the extensive heath tracts that arose thru over-cutting, grazing and successive fires at short intervals. The existence of the sharp contrast between these productive and unproductive lands, under parallel conditions, point a moral that cannot fail to impress even the most superficial thinker. Protection of trees against organic and human enemies is an obvious necessity even in these parts of the world that possess an oceanic climate. How much more emphatic is this truth in such lands where general low atmospheric humidity tends to put vegetation, especially tree growth, at a disadvantage in the struggle for existence; while at the same time, it favors insect and animal life as well as fire.

All Scandinavia exhibits obvious evidence of glaciation. Scientists do not exactly agree as to the length of time which has elapsed since the great Arctic ice-cap finally retreated. In all probability there were long centuries of fluctuation, when the ice sheet alternately advanced and retreated. In fact some authorities present plausible evidence to support the theory, that our modern age is only one of such inter-glacial periods as several times before coaxed vegetation up into boreal regions, only to later gradually overwhelm it. Undoubtedly southern Sweden has supported forest stands much longer than the more northerly portion of the land. It is estimated that about 12,000 years ago willows, birch, alder and aspen began to invade the land from the south over the islands that are at present represented by Denmark. Light seeds adapted to wind dispersal, and ability to grow on relatively raw mineral soils under unprotected open sunlight and wind conditions, were a necessary characteristic of these pioneer trees. The common European pine (*Pinus sylvestris*) possessed these attributes and soon followed the light-seeded hardwoods. Later came elm, basswood, oak, and finally beech. Meanwhile spruce had also made its appearance, but it crossed over from Finland by way of intervening islands and probably never occurred naturally in southernmost Sweden or Denmark. Its more rapid conquest of the less hospitable areas to the north, as compared to warmer soils southward, was probably due to the preemptions of the latter regions by such tolerant species as beech and maple, and the fact that its seeds are nearly powerless to successfully germinate and establish themselves on a thick and undisturbed soil cover of hardwood leaves [12–2/1924–4]. There are reasons to believe that ancestors of the present Norse peoples occupied Sweden 7,000 years ago and have been in uninterrupted possession ever since.

This background melting away into the prehistoric past is probably unparalleled by any branch of the Caucasian race when considered in the light of the dark forests, soil of predominant rocks and bogs, with long and severe winters; hence it is not surprising that the people looked to the sea for many centuries as the chief and most reliable source of food, as well as an open highway over which the adventurous could always go to warmer, and richer climes. The everlasting struggle with the natural elements, in a land where conditions are relatively unfavorable to primitive man, account for the self-reliance and perseverance typical of Scandinavian folk.

The fact that man so long bent his efforts to the conquest of the sea, permitted a great bulk of Swedish forests to stand untouched down to modern times. Only near the sea-coast centers of population was the forest heavily drawn upon by the old vikings and their more cultured successors.

GENESIS AND DEVELOPMENT OF LUMBER EXPORT TRADE

The population of Sweden has always been sparse. A comparison with Japan as to area and density of population is enlightening. These two countries have nearly equal areas (Sweden = 173,151 sq. mi. Japan = 173,333 sq. mi.), but Japan's population is more than ten times that of Sweden, which has now 5,988,000 people. All European lands to the south and west of Scandinavia support denser populations and possess much smaller forest areas per capita. These facts, together with accessibility by sea, early led to the exportation of timber and lumber. This business seems to have first attained considerable proportions under the stimulus of the Hanseatic League. The rich and ambitious mercantile cities composing this admirable alliance early began to look to Sweden for supplying their needs respecting hewn and round timber. The Dutch merchants from the Netherlands succeeded to this trade when the League lost its grip. Holland has continued down to the present a good customer for the forest products of Sweden, but has been relatively of much diminished importance during the last two centuries. In those olden days Sweden shipped logs as a rule, which were sawn in Holland, England and other importing countries; by marked contrast with the present, when except for a practically compensating trade with Norway, no logs are exported.

The eighteenth century was a period of transition in Europe in many respects. Great Britain became a dominant purchaser of forest products, and still retains this position. For several decades before and after the dawn of the nineteenth century, the lumber trade was hampered and restricted by England in an effort to confine importation to the products of her American colonies. Sweden had also numerous and varying export taxes, regulations, and embargos; some of which continued in force until about 1850 [51–64].

The great period of development in the Swedish lumber industry began with the abolition of English tariffs in 1866. This liberal and progressive step by Great Britain was the greatest boon Scandinavia ever received from an exterior source [49–4/1925–7],—if Christianity be excepted. There was doubtless mutual benefit from the increased and more profitable trade that at once arose. The Swedish forests quickly began to show the effects of the heavier drafts they were called upon to meet. This resulted in the construction of larger new mills along the northwest coast of the Gulf of Bothnia to utilize the extensive but rather inferior virgin stands in Norrland. It also caused a national awakening to the fact that while forests were a renewable asset, they were not inexhaustible. It demonstrated to statesmen and economists that the standing of Sweden as a cultured and prosperous nation depended absolutely on its ability to capitalize and stabilize the forest upon a sustained yield basis; since international trade balances could only be struck by means of the direct and indirect forest products. The development of the pulp and paper industry, while in part at the expense of sawed lumber production, was still a great aid toward improved foreign trade and permitted the utilization of small size spruce at a profit. Without the ability to utilize closely, intensive forestry is practically impossible.

EXPORTS IN WAR-TIME

Because of European politics and resultant wars during the past four centuries, Russia and Sweden are traditional enemies. If the ambitions of monarchs be omitted from the equation, there would be no real reason for this state of affairs. Yet it existed when the World War broke in 1914, and tended to throw Swedish sympathy to the Central Powers; altho the entrance of the United States later definitely guaranteed that the country would continue to maintain its neutrality.

The general opinion seemed to prevail at the end of the War that Sweden had profited notably thereby. This was in general an erroneous assumption. The country had its crop of war-profiteers and get-rich-quick millionaires, but the upper classes were impoverished, to an equal degree, and the laboring population achieved only apparent and fleeting benefits. A study of export statistics [45–264] reveals only relatively small increases during the war years if quantities rather than values are considered. In fact, the attempt to develop manufacturing plants, drew so strongly upon the labor resources of the country that it was often impossible to take out the normal cut on many forests. The efficiency of labor also decreased as wages rose; in part as a consequence, however, of the allied blockade, which included Sweden in the iron ring thrown around the Central Powers. Food consequently became very scarce, high in price and often of low nutritive value. If people did not actually starve to death in Sweden, there is no question that numbers died of malnutrition and many, especially among city-dwellers, were physically weakened. In Stockholm the flocks of pigeons, typical of many streets and public buildings, were nearly exterminated. Foods of high cellulose content were used by man and beast [45–172]. Considerable quantities of Iceland and reindeer moss (lichens) were milled together with whole rye and oats to supply the country with war-bread. The forest was also called upon directly in some localities. Buds and twigs of birch, as well as the inner bark of certain trees, in particular pine, have often helped dwellers in remote regions to tide themselves over starvation times. These sources of nourishment are usually made available by drying and roasting to crisp brittleness, after which they are milled to as fine a flour as possible and baked or otherwise cooked in mixture with other more common sources of human nourishment.

The German U-boat warfare also curtailed exports and kept insurance on shipments to the allies at extreme levels, even if it were possible to find bottoms to carry such cargoes from the Norwegian ports. Indirectly, the heavy exportation of metals and manufactures stimulated intense forest utilization by creating a lively demand for all sorts of fuel; especially charcoal. The Central Powers also offered attractive prices for resin, tar, turpentine and wood distillation products. It became quite profitable to tap the common pine for naval stores and dig up stumps for fuel or destructive distillation. This kind of market is, however, never an unmixt blessing. After the German collapse considerable losses had to be accepted, and the reaction left a feeling of discouragement to which some forest owners still give voice.

SWEDISH UNITS OF MONEY AND MEASURE

The three Scandinavian lands have the same monetary system. It is based on gold. The unit of value is the crown (krona, = kr.) divided into 100 öre. For years the minor coinage of all three lands circulated in common, but since Sweden was the only country in northwestern Europe whose money maintained parity with the dollar during the past decade; as a measure of self-defense against " bootlegging " of Danish and Norwegian coins, their circulation was forbidden in 1924.

The metric system is established by law, but English units are much used in forest utilization and the lumber industry. The old Swedish units still persist in some localities. In fact, there very recently existed very grave confusion in methods of measuring cord-wood and similar products [24–10], as exemplified in the " famn." A careful study in 1923 showed eleven different kinds of famns in use, varying in size between 75 and 360 cu. ft.

Since American students and foresters commonly think in terms of the units in everyday use, all denominate numbers have been con-

TABLE I.—CONVERSION OF DENOMINATE NUMBERS

Units	Abbreviation		Approximate Equivalent	More Exact Equivalent
1 krona	kr. (plural = kronor)	=	$0.27 —	$0.26799
1 dollar	$	=	3.73 kr.	3.73148 kr.
1 pound (avoirdupois)	lb.	=	0.37½-(⅝) kg..	0.37324 kg.
1 kilogram	kg.	=	2.2 lbs.	2.20463 lbs.
1 centimeter	cm.	=	0.4-(⅖) in.	0.3937 in.
1 meter	m.	=	3.28 ft.	3.28083 ft.
1 meter	m.	=	1.1 yds.	1.093611 yds.
1 Swedish foot	Sw. ft.	=	1 ft.	0.9741 ft.
1 kilometer	km.	=	0.625-(⅝) mi.	0.62137 mi.
1 Swedish mile	Sw. mi.	=	6.6 mi.	6.64233 mi.
1 square centimeter	cm^2	=	0.155 (⅐) sq. in.	0.155 sq. in.
1 square meter	m^2	=	10.75 sq. ft.	10.764 sq. ft.
1 square meter	m^2	=	1.2 sq. yds.	1.196 sq. yds.
1 square kilometer	km^2	=	0.38 (⅜) sq. mi.	0.3861 sq. mi.
1 square kilometer	km^2	=	247 acres	247.104 acres
1 hectare	har.	=	2.5 acres	2.471 acres
1 are	ar.	=	4 sq. rds. (1/40 A.)	0.0247 acres
1 tunnland	tunnl.	=	1.22 acres	1.2198 acres
1 cubic centimeter	c.c.	=	0.06 cu. in.	0.061 cu. in.
1 cubic meter	m^3	=	1.3 cu. yds.	1.3079 cu. yds.
1 cubic meter	m^3	=	35 cu. ft.	35.314 cu. ft.
1 famn	fm.	=	108. cu. ft. (usually)	108. cu. ft.
1 liter	lit.	=	1 qt.	1.05668 qts. (liquid)
1 liter	lit.	=	0.9 qt.	0.9081 qts. (dry)
1 hectoliter	hl.	=	2.8 bu.	2.83774 bu.

verted to facilitate the ready comparison and understanding of subject matter. When not otherwise designated, the more exact values from Table I have been used in making conversions.

ACKNOWLEDGMENTS AND AUTHORITIES QUOTED

In the appendix hereto attached is found a partial list of books, periodical articles and reports on which this description and discussion of Swedish Forestry is based. No merit is claimed for original investigation and conclusions, as most of the compilation is simply translated and condensed from works available in the Swedish, but in a large measure unfamiliar to forestry students and economists in English-speaking lands, due to our general lack of interest in a language spoken by less than 8,000,000 people, who are themselves among the world's best linguists, with a generally proficient knowledge of English.

The writer spent nearly a year in Sweden, devoting much of his time to studying the literature of Scandinavian forestry available at the State Forestry College and Experiment Station. The instructors and research men at both of these institutions were always courteous, helpful, and efficient in putting at his disposal every facility that might aid toward a rapid acquirement and accurate grasp of forestry as a science and business in Northwest Europe.

Publications of the U. S. Dept. of Commerce, written by Axel H. Oxholm, and several quoted articles from the *Journal of Forestry,* are about the sum of recent American contributions toward a better appreciation of the progress rational forestry is making in this part of the world.

WHY SWEDISH FORESTRY IS A USEFUL GUIDE TO AMERICA

Only a small part of America possesses a climate and forest condition similar to Scandinavia; hence direct application of the same conclusions and methods in the two regions is generally impossible. It is chiefly by comparison, adaptation and parallel investigation that the older European experience becomes valuable.

A decade ago Americans held a prevalent opinion that Sweden and Norway were in about the same stage of forestry development as Russia, Canada and Finland; with cultivated areas and thriving towns toward the south where farm-woodlands received good care, but northward grading into vast cut-over areas and uncared-for lands that would not again yield a timber crop for a century or longer. Still further north were pictured the inferior remnants of the original virgin forests, with the well-developed lumber, paper-pulp and match-manufacturing industries clinging precariously to their margins. Even the very names " Kronopark " and " Jägmästare," when translated literally into English as " crown park " and " master of the chase," gave the impression that such forestry as existed, would not be the practical kind which alone can be successful in the New World. With such a concept of forest conditions and management in Scandinavia, it is not surprising that American foresters in search of ideals that might serve as models for their future efforts, always wended their way to Central Europe or France.

The quite extensive Swedish forestry literature has been translated and abstracted to a considerable extent, and it is but a matter of time now until American forestry fully realizes that here is found the most adaptable European practices, as well as much of the soundest scientific progress made in recent years along silvicultural lines. Among all the nations of the earth, only Japan can compare favorably with Sweden in forestry progress during the past fifty years. The rapid strides in the practice of forestry were due to an economic stimulus, in which the iron industry was an important factor. Proximity to England, the world's greatest lumber buyer, and recent rapid development of the pulp and paper industry, have vied with charcoaling in improving the market for forest products of high and low quality. It is the demand for small-size material which has mostly been responsible for the present rational intensive silviculture. The glacial soil, oceanic climate and high latitude of Scandinavia also help to keep it a land of forests. Had the soil been easily tilled, they would have long since vanished.

Due to the above listed causes, there are today, in both Sweden and Norway, many large and small forest units, under both private and public ownership, whose age-classes are practically normal and whose present annual productivity, or sustained yield, is assured in perpetuity. It is such forests and such a complex of economic and industrial circumstances, that merit special attention from American foresters, publicists, lumber interests and land-owners in general. It will be seen at a glance, that conditions here have much more in common with America than is the case in Central and South Europe with their teeming millions. The entire population of Norway and Sweden is but 8,000,000 souls, of which about 80% live in the southern third of the peninsula and most of the rest on the sea-board. The terrain is also quite difficult, and areas are larger than one might think. Sweden has about the same area as Indiana, Pennsylvania, New Jersey and New York combined. From Törne Träsk, near the northern limit of forests, to Trelleborg is as far as from there to Rome. It is therefore all the more encouraging to see good organization and scientific methods make forestry a success here, where the ultimate consumer is located on the average a thousand miles or more from the forest, under a foreign flag, speaking a different language, and often with national suspicions and tariff restrictions hindering normal trade. Here also are a great variety of forest conditions and problems, ranging from the sand dunes and beech forests of Halland and Blekinge to timber-line tracts in Lapland, clad with sparse and poorly formed birch, pine and spruce. The rocky and broken seacoast, extensive heath moors, poorly drained peat bogs, degenerated pineries and interior alpine areas have all received attention from forestry experts, and hence help to broaden the educational possibilities so well illustrated on the country's present 60,000,000 acres of productive forest soil and by the intelligent use of the numerous rivers and streams for power development and timber transportation.

The foregoing characterization of Sweden from a forestry standpoint, reveals many features comparable to conditions in America, and several that justify special consideration; for example, the system of crown forests, owned and managed by the central government. These areas lie to much the greatest extent in North Sweden, and include there a considerable volume of over-mature, depreciating and relatively inaccessible timber. They are composed of lands never alienated from the crown to which additions have been and are still being made by purchase and other methods of acquisition. The net income from the state forests for many years past has averaged between 50% and 60% of the gross return, which is an eloquent argument in their favor. Additions by purchase have been relatively small in recent years. Prices paid are illustrated by reference to 1921, when some twenty small areas were bought up for 291,000 kronor. Their combined area was 1,042 hectares, which was equivalent to paying about thirty-two dollars per acre.

Silviculture is the field of forestry to which Sweden gives most attention. It is in this subject that present and future attainments show greatest promise. The Experiment Station has more than a thousand permanent sample-plots with upward of 450 hectares (1,100 acres) area, and four research forests, devoted to methods of regenerating the forest and getting from it a maximum wood production. The motto, "Try everything," seems to prevail here, and literally hundreds of parallel projects for American conditions are suggested by even a casual study of what Sweden is doing.

Forest and wood utilization in Scandinavia is on a scale nearly proportional to that met in America, if the Douglas fir and redwood regions are omitted from consideration. The secrets of economy and organization for efficiency are needed in American forestry and lumbering. The kind met in Swedish theory and practice has a good measure of direct applicability to Canadian and eastern United States conditions. It exhibits many phases that stimulate thought, especially in connection with the coördination of several wood-using industries, so that waste is eliminated and the use of natural instead of costly railroad transportation.

The good public support accorded forest management and research in Sweden should have its counterpart in America; more so, because of our republican forms of government, which makes the diffusion of general forestry information imperative. Conditions in all the Scandinavian lands in this respect are truly ideal, and a short description of the organization developed in Sweden cannot be without interest.

The above citations serve to demonstrate, in a general and limited way, the fertile field for study which invites the thoughtful and observant forester in Sweden, the unsurpassed land of forests and waters.

CHAPTER II

LEGAL STATUS OF FORESTS IN SWEDEN

In general, the land laws of Scandinavian lands in the historic past have been identical with those once prevailing in England, but in the latter country and other English-speaking lands, individualistic ownership was more completely attained, and more generally accepted as the ideal status of land and the natural resources which the word includes in its wide sense. For many centuries ownership of land implied that the holder was entirely unrestricted in his possession, and fully entitled to both use or abuse of his property, so long as adjacent owners did not suffer thereby. The reaction against this thesis of early economists came in Sweden about 1870 [51–116]. It was not due to a realization that land is the world's greatest natural monopoly, but to the fact that soils of meager productivity suffered under private possession and at times became liabilities or even menaces to society, instead of permanent productive assets.

REGULATION OF PRIVATE FOREST MANAGEMENT [45–54]

As long ago as the thirteenth century certain more or less effective laws and orders existed in Sweden regulating or restricting timber cutting on commons and other public owned forests; but private owners until very recent times were quite untrammeled. Yet today practically all of such forests are subject to one or another law especially adapted to conditions in different parts of the country.

Since restrictive laws upon private forest owners in the United States and Canada are at present an open question, a brief résumé of the chief features of these Swedish laws is given below. They should be much better adapted to our conditions than are the restrictions in force in France and central Europe, since great areas of the private owned forests in Sweden are essentially virgin growth, located in a sparsely populated region thousands of miles from market and subject thruout nearly all the last century to full and free exploitation by a people who are rather resentful of interference in what they consider private affairs.

The " Lappmark Law " deals with the interior forests of the two northern provinces and a small part of Dalarna. It was in force during the entire last quarter of the past century, and provided that, except for needs of the owner, no timber should be cut until it had been marked by a government forestry official, who first inspected the whole property and restricted commercial exploitation to the approximate volume growth. As the rotation for production of saw timber under the adverse climate of these areas is about 200 years, the allowed cut was usually rather low, in spite of the fact that a large quantity of stagnant or even deteriorating stock was present. Dissatisfaction with the law gradually increased as market prices rose, so that it was liberalized in 1915 to permit the more rapid salvage and utilization of the hypermature timber and its replacement by young trees with better increment possibilities. The law is only concerned with coniferous stands. The forestry officials draft utilization plans for each owner and usually mark the cut for three-year periods at a time. They may also permit heavier cutting where an owner has his forest under a definite working plan and takes approved measures to insure prompt reforestation of cut-over tracts.

The " Dimension Law " related to the coastland forests of the two northern provinces. It provided for cutting to a diameter limit. No coniferous trees below this limit could be cut unless with the approval of the government forestry authorities, or for local use within the two provinces. The limit of the cut was set at 7″ in diameter at 15′ above the ground. The purpose of this law was to prevent devastation of forest areas whose chief growth was thrifty growing young trees that found ready sale as spars and for cutting into small dimension stock. It was first effective about 1875, but never served as a desirable basis for silviculture or management, and in 1925 was replaced by the " General Forest Protection Law," which has hitherto applied to most of the rest of the country's productive private forests.

The islands of Gottland and Öland, in the Baltic Sea, have a climate characterized by an average annual fainfall of 16 inches, much of which falls in the autumn. They are also open to strong winds and have over large areas a soil rather poorly adapted to forest growth. The dwindling and degenerated forests caused the promulgation of a special law for Gottland in 1869. This law has been somewhat modified since, and applies to Öland also. It is executed in the same way as the General Forest Protection Law, but is somewhat more stringent. All cutting of timber and wood, except for domestic use upon the immediate property of the owner or lessee, must be after marking by, or according to prescription of a forest officer of the local Forest Protection Commission. If the prescribed measures are neglected, the commission, after judicial proceedings, is empowered to do the necessary work at the expense of the land-owner or lumberman. Results under this law have been quite satisfactory, but its enforcement is a slow, up-hill struggle to rectify the mistakes of centuries.

The " Protection-forest Law " [51–133] for the most part deals with a mountainous area similar to that covered by the Lappmark Law, but its field lies south of most of the tracts covered by the latter, and is on the whole more habitable. The law also applies to certain sand dune areas in South Sweden. Except in special cases, it applies only to commercial cutting of the forest, but can be extended to cover all cutting whatsoever. It requires that a government forest officer mark the trees that may be cut, " limiting the yield to such bounds as are consistent with reproduction and future outlook of the stand." It is hoped that the law may be improved by addition of some positive provisions concerning management of the stands in question. Yet it has been a means to keeping a forest cover upon areas that are very difficult and expensive to reforest if they be once denuded. The law was originally passed because unregulated cutting near the limit of the growth, at high elevations, had resulted in the timber line being constantly pushed downward.

The "General Forest Protection Law" for private owned areas, as originally enacted in 1903, related strictly to reproduction. This was its weak point; as it could not stipulate cutting methods for a forest stand. Hence certain sites, with extremely adverse conditions, were sometimes treated in such manner that reforestation even by planting became nearly or quite impracticable. Young forests were also at times cut ineconomically. The defects in the above respects became especially obvious during the war years and led to a provisory amendment whereby speculators and recent purchasers of forests were closely restricted and the executive organization, the provincial "Forest Protection Commissions," or their qualified trained officers, might forbid cutting of young forests unless the work be in the nature of a thinning with the future development of the stand always in view. The law does not concern areas being cleared for agriculture or cutting of wood for use on the property in a domestic way. The commissions may even permit clear cutting of young forest stands if it be in accordance with good forest economy to do so. Infractions are punishable by fine, confiscation of the wood cut; and complete prohibition of further commercial operations; but such decisions of the commission are subject to judicial review upon appeal of the forest owner or operator. In 1923 the general forest protection law was still further strengthened. In addition to being responsible for the reproduction of their forest after lumbering, owners and operators are now under compulsion to reforest after natural calamities and destruction of plantations by grazing, altho in these instances they need not spend more than the value of the stand prior to the calamity.

The law also contains special restrictions, quite like those in the law for Gottland, which are to apply to a class of land termed "Forests difficult to regenerate." The island of Öland will be included in this class as a whole and its forests supervised in the future under the general protection law. The law now holds the land-owner primarily responsible for his property and the operator who cuts timber therefrom stands in a secondary position, which is exactly the reverse of their positions under the original law of 1903.

The poorly drained forest areas are excluded from the law's jurisdiction.

The general execution of the law is on a basis of assistance and advice to the forest owner. He is also furnished tree seeds and plants at cost or probably slightly less. Yet there are teeth in the institution. If orders of the commissions and their executive officers are disregarded, the latter secure a legal injunction in support of their stipulations and in default of obedience by the owner or operator, execute it themselves at cost of these parties.

The constitution of the " Forest Protection Commissions " may explain why they have functioned as well as has been the case. They consist of three members serving without pay for three-year terms. One is appointed by the central government, one by the provincial court and one by the executive committee of the Agricultural Society of the province. There are now commissions in each of the twenty-four provinces, since the dimension law for the north has been repealed. These commissions select their personnel under certain restrictions. Their chief executive must possess thorough technical forestry training, and in the larger provinces he has one or more similarly trained assistants. They also choose provincial inspectors (*skogs vaktare*) or wardens. These officials are of two classes: permanent wardens with definitely defined districts, and special wardens who serve as assistants to the former as occasion may require. In many of the parishes the provincial commissions have branches called " Forest Protection Committees," consisting of three reliable local residents whose duty it is to supply, upon request, information concerning cutting in the forests, seeding, planting and relevant local facts [26–121].

The commissions pay their personnel and usually conduct a considerable business in seed collection, extraction and sale, forest nursery operation, sale of seedlings, forest land drainage, execution of direct seeding operations, planting and such other work as may be necessary to the perpetuation of productive forests upon all suitable soils not devoted to higher uses. Their finances are audited by a board of three officials; one of whom is appointed by the government, one by the provincial court and one by the agricultural society. The commissions are also required to report on their activities to all three of the above mentioned social units. Triennially, all the commissions meet together, and even oftener the provincial foresters hold conferences, so that a certain unity and uniformity in administration of their duties is thus secured thruout the realm. The Forest Protection Commissions derive their monetary support from several sources, as already incidentally mentioned, but in addition thereto they receive the income from a special " Forest Conservation Tax." This is a severance tax, paid by all forest owners who cut timber in excess of an annual net stumpage value of $40.20. These owners pay as tax 1.3% of such net value. The central government, as well as the provincial authorities and organizations, also contribute funds toward support of the commissions. Thru their activities considerable areas of waste land have been rendered productive or retained in productivity. The loyal coöperation of most forest holders has been given always. " Only the robber knights of the forest and the devastators have had reason to complain about the severity of the forest protection laws and the officials who administer them."

Table II gives a vivid idea of the general satisfaction with which

TABLE II.—Activities of Provincial Forest Protection Commissions

Years	1907–09	1910–12	1913–15	1916–18	1919–21
Number of Cutting Projects examined	13,073	15,948	16,892	19,627	36,149
Number of Contracts for Seeding and Planting executed	4,991	3,869	3,456	3,576	9,412
Law Enforcement Investigations	531	460	266	337	1,174
Enforcement Law Suits	106	117	100	56	131
Total Incomes (dollars)	874,610.	940,696.	1,118,589.	1,701,154.	3,953,012.
Total Expenses (dollars)	755,655.	962,450.	1,169,402.	1,344,875.	3,837,454.
Area of Forest Plantations made with advice and aid of Commissions (acres)	148,463	145,910	209,119	232,326	286,853
Trees distributed by and thru the Commissions (millions)	70	92	159	232	251
Quantity of Pine and Spruce Cones bought by the Commissions (bushels)	51,640	178,239	389,727	189,044	185,225
Seeds sown in cooperation with Commissions (lbs.)	115,500	100,100	118,170	193,120	130,960
Miles of drain ditches dug with assistance of Commissions	4,361	5,090	5,549	2,016	5,468

the forest protection commissions have met in general and over a long period of time [26–123].

The total mileage of ditches above mentioned is nearly sufficient to girdle the earth, and is all new work, which increases the productive forest area. The forest protection commissions draft drainage plans after best approved principles for private forest owners. They also contribute a portion of the cost of executing these plans; in some cases as much as half the first cost of the work.

The extensive seed collection and extraction activities of the commissions is illustrated in Table II. In 1923 there were forty-five coniferous tree seed extractories in Sweden, of which seventeen were operated directly by, or in close coöperation with the forest protection boards. It is therefore apparent that these commissions long ago grasped a very essential truth, which is probably the crux of the forestry problem in most lands;—the *surest and best way to forest protection and conservation is by forest extension.* Positive progressive action is always preferable to defensive conservatism.

FOREST OWNERSHIP

The value of forests and their advantages as permanent investments has been recognized generally for the past eighty years. This fact accounts in part for the fact that in Sweden are found all types of both public and private ownership [26–182]. The total area of public forests of all types is 12,491,198 acres, or 21.6% of the productive forest total of 59,340,100 acres. The privately owned area of 46,848,902 (78.4%) has steadily tended to increase due to former agricultural and grazing lands being permitted to revert to forest, or being planted up, and the constant reclamation of marshes and other unproductive land types. The public forests may be divided logically into two groups: (1) the "Kronoparks" and other state lands whose income goes into the "Domain Fund" of the central government; (2) public forests whose income goes to other institutions and governmental units than the central state. Table III gives a condensed summary of the public forests by major divisions of the country.

Private owned forests are divided, for purposes of statistical consideration, into three groups [22–270]:

1. Corporation Owned	16,635,807 A.
2. Large Estates	3,035,181 A.
3. Farm Woodlands and Other Small Properties	26,848,784 A.
Total Private Owned	46,524,714 A.-X

The distinction between the last two groups is based on area and value. Under "large estates" are included all properties exceeding 247 acres (100 har.) area, or an assessed value of $53,600. These larger properties are located to far the greatest extent in south and south central Sweden. But the large corporate holdings, on the other hand, are very much the most important in Norrland. The very extensive forests in the ownership of the smaller working farmers is highly gratifying from a social and political standpoint, but from the

TABLE III.—PUBLIC FOREST OWNERSHIP BY AREAS

Domain Fund—Public Forests	South (acres)	Central (acres)	North (acres)	Totals (acres)
1. State (or National) Forests	691,566	1,476,658	6,281,715	8,449,939
2. State (or National) Forests—under Lease	189,312	6,556	239	196,107
3. State Forests devoted to Special Ends	12,431	1,893	2,782	17,106
4. Unsurveyed and Unallotted Lands		37	723,883	723,920
Totals	893,309	1,485,144	7,008,619	9,387,072
Miscellaneous Public Forests				
5. Forests assigned to Private Manufacturing Interests	30,423	5,372	18,513	54,308
6. Lapp Reindeer Grazing Lands		407,436		407,436
7. Church Lands for Homes and Salaries	367,009	243,878	65,956	677,843
8. Crown Estates and Allotments	15,416	408	553,350	569,174
9. County Forests	197,160			197,160
10. Parish or Communal Forests		489,489	536,788	1,026,277
11. Town and City Forests	64,394	22,888	17,324	104,606
12. Forests held by Public Institutions		2,347	65,975	68,322
	674,402	1,171,818	1,257,906	3,104,126
Grand Totals—All Public Forests	1,567,711	2,656,962	8,266,525	12,491,198

economic angle, this type of holding is not so desirable; because these farm woodlots and small forests are on the average the most poorly managed and least productive woodlands of the country, when their native fertility and potentiality are considered. The representation of the different classes of owners in the three important sections of the country on a percent basis is given in Table IV.

Author's Note.—Swedish statistics on total area of private owned forests show a discrepancy of more than 300,000 acres.

TABLE IV.—PUBLIC AND PRIVATE FOREST OWNERSHIP

	Portions of the Country			All %
	South %	Central %	North %	
Corporations	8.	31.6	34.3	28.1
Large Estates	10.3	9.4	1.2	5.1
Farm Woodlands and Small Properties	74.2	45.9	33.8	45.2
Public Forest Lands	7.5	13.1	30.7	21.6

It is difficult to overestimate the stabilizing effect of the fact that more than a fifth of all forest lands are publicly owned and managed as intensively as economic conditions permit. It will be noted that these forests are found in all parts of the country, altho as is true of our national forests in America, the kronoparks are relatively much the most important in the inaccessible sections. The considerable areas of communal forest tend to hold the populations of some localities due to their part ownership therein; and are generally under exemplary management, thus serving to prevent emigration and illustrate how nearby privately held woods may be made most productive.

FOREST OWNERSHIP IN DENMARK, FINLAND AND NORWAY

In all the lands around Sweden are found publicly owned and managed forests that pay their way, as shown in Table V. These

TABLE V.—OWNERSHIP OF PRODUCTIVE FOREST LAND IN COUNTRIES ADJACENT TO SWEDEN, WITH RECENT INCOMES [77]

	Denmark	Norway	Finland
Held in Private Ownership	47.1%	78%	64.9%
Publicly Owned and Managed			
State	24.	15.	33.5
Communal and City	2.	6.	.8
Associations and Church	27.	1.	.8
Net Income per Acre in 1926 for Productive State Forests	$2.75	$.32	*

*The state owned forests each year yield a handsome net return but it is not easy to state this so it will do them justice, since vast areas of land held by the Finnish government are very remote and inaccessible. The depreciated and rather unstable monetary system in 1925 and 1926 also gives rise to complications. [70-4/1927-208].

lands are as a rule quite below the average in productive capacity. They were organized into efficient units for forest management for about the same reasons and in nearly the same manner as is outlined in some detail for Sweden.

HISTORY OF STATE FORESTRY IN SWEDEN [45–43]

Since the beginning of history great areas of forest have been held by the king or central government. Much of the vast unoccupied tracts of northern pine and spruce have only achieved a positive value during the last few decades. The forests of the more settled sections of the country were gradually distributed and allotted as civilization reduced the better lands to culture. Many such allotments persist at present as large estate forests of the more or less defunct nobility, church lands, communal and town or city forests. The greatest portion, by successive transfers and sub-divisions, became the farm-woodlands that are everywhere important in Sweden today. The residue retained was chiefly prized as royal hunting grounds or a source of naval timber. Even as early as 1638 fear was felt that the important supply forests were tending toward exhaustion, and rules were laid down for better forest management and exploitation. A hundred years later the government even engaged in extensive seeding and planting projects in South Sweden, especially in localities where drifting sand and recurrent forest fire had emphasized the importance of forests and their need of protection and assistance from man. Yet at the same time these early activities gave promise of the development of conservative forestry such as then characterized central Europe, a different undercurrent in political economy unfortunately delayed the movement for another century or more. The teachings of Adam Smith had a profound influence upon political thought everywhere, and especially in Sweden, so that in the early nineteenth century the government sold at very low prices, to private individuals and corporations, great tracts of the country's best forests. Large grants and concessions were made during this period to sawmilling and mining concerns. In some cases lands were granted in fee simple and in others liberal cutting rights were practically donated; so in many instances vested rights were thus acquired by private interests almost amounting to ownership. This alienation of the State's forest holdings was due to the prevalent opinion that governmental management and exploitation would be inefficient, if not worse. This policy of sale accounts for the relatively small proportion of State forests in south and south central Sweden, and to the fact that the holdings there are very much broken up and scattered so as to be difficult to protect and administer [51–66 to 72]. Not until 1875 did the pendulum swing definitely in the other direction. At that time the government formulated a policy of land acquisition for management as national forests or " Kronoparks." This acquisition of land has been only in a small part by purchase. To a great extent the kronoparks are composed of areas once otherwise held by the crown or central government, and only thus recently set aside for rational forest management. Some of the largest areas of these lands, in west central and north Sweden in particular, were acquired by making definite allotments of land from the unfenced public domain to local settlers and communities who had a more or less legitimate claim to an interest in nearby areas. After the ownership of such local claimants was confirmed as regards certain areas, all the residue was assigned for use as productive forests under the well organized forest service, which dates from about 1860.

The purchase of lands for addition to the kronoparks is still in progress. Table VI gives a summary of such purchases by provinces for the year 1923 [66–x55].

TABLE VI.—Land Purchased for National Forests in 1923
Areas (Acres)

Province	Cleared Land	Forest	Waste Land	Total	Purchase Price ($)
Vesterbottens	0	390.3	0	390.3	3,159.79
Gevleborgs	42.8	988.3	139.2	1,170.3	35,632.67
Östergötlands	144.6	867.7	232.6	1,244.9	73,697.25
Gottlands	0	25.9	0	25.9	1,607.94
Skaraborgs	0	0	3.8	3.8	146.60
Kalmar	60.6	677.2	63.	800.8	28,138.95
Blekinge	106.7	513.4	33.3	653.4	46,094.28
Total	354.7	3,462.8	471.9	4,289.4	$188,477.48

Average price paid per acre for all the above lands is $43.94. In the most northerly province the average price paid is $8.10 per acre. The prices increased steadily until we reach the last and most southerly province, where $70.39 was paid per acre. The above table does not include building lots or improved properties bought for ranger residences or similar uses.

The sums expended for land purchase vary from year to year. In 1922 only 1,462 acres were bought at a total cost of $57,621.00.

Table VII shows the course and total of land purchases for addition to the state forests by five-year periods since 1875.

TABLE VII.—Land Purchased for National Forests to 1895

Years	Areas Purchased (acres)	Years	Areas Purchased (acres)
1875	4,743	1896–1900	332,151
1876–80	28,090	1901–05	135,300
1881–85	2,355	1906–10	123,194
1886–90	110,344	1911–15	125,712
1891–95	116,126	1916–20	30,821
Total			1,008,836

This table includes both productive and waste lands; a certain portion of the former being cleared, and if of quality adapted to permanent agriculture, was later retained in cultivation of lessees.

The average annual area purchased during the whole period was 21,942 acres, from which it appears that purchases have much decreased during recent years. (See Table VI.)

The forest land purchases of the Swedish state has been to a small degree counterbalanced by the colonization policy of recent years which will be discussed in detail later. It has not, however, resulted in the alienation of any considerable area of forest, due to careful safeguards. It applies only to unimproved land where a thoro examination shows good natural fertility and possibility of comfortable homestead development.

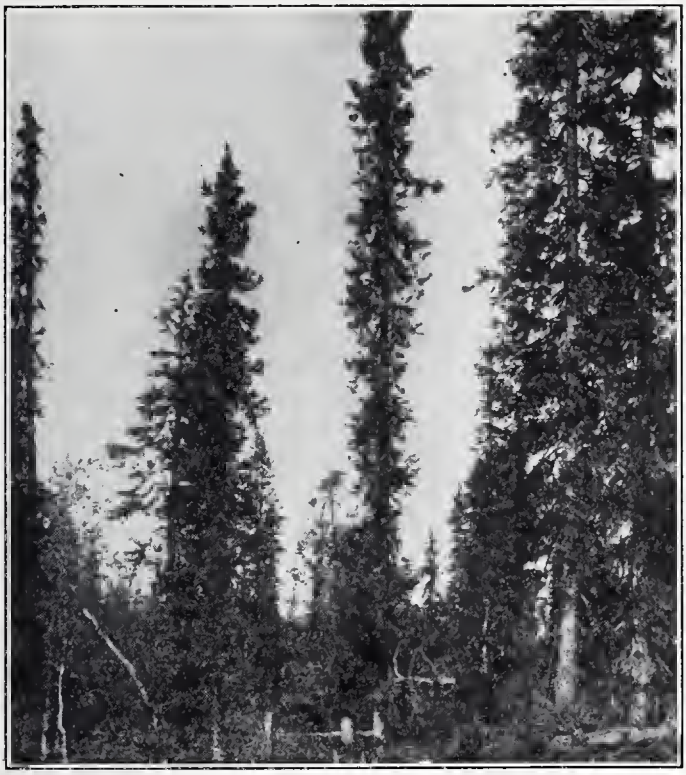

FIG. 1.—SPRUCE FOREST IN NORTH SWEDEN THAT HAS SUFFERED FROM DIAMETER LIMIT CUTTING.

These trees show the typical form of Norway spruce found in the far north with many small and often drooping limbs. Such a "Scrap stand" as this is subject to so many dangers that it has little possibility of future development.

One very great advantage was derived from the sale policy, destructive and ill-advised though it was. It practically eliminated prescriptive rights upon the national domain which remained. In

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fact, the " Rights of user " was the commonest consideration which passed in these transactions, much to the dissatisfaction of the statesmen, who hoped the government might derive a big cash revenue therefrom. The actual income realized was only a trifling fraction of the values with which the state parted. The credit item above mentioned is quite important, however, and gives the state forest administration, so far as freedom of action is concerned, a marked advantage over the extant status in Central Europe generally.

TECHNICAL ADMINISTRATION ON STATE FORESTS

The national forests are managed under the " Domain Commission " (Domänstyrelsen) of the Department of Agriculture, at whose head is a general director and which is divided into nine bureaus, of which six are essentially devoted to handling the forest lands. In addition to forest soils, the commission has charge of the very extensive improved agricultural properties belonging to the " Crown " in an official rather than a private sense; as well as waste tracts of wet and hopeless marsh, rocky ridges and alpine treeless barrens or reindeer grazing lands. This central forest service also administers, either in detail or in a general way, all the other public owned forest land. The extent of this latter administration is quite variable and often seems to depend upon whether or not a given property is under the direct supervision of a forestry-trained manager employed by the owners. Many church, communal and county forests are entirely handled by the central forest service along with the state-owned areas and practically without restriction, except that incomes are separately accounted for and turned over to the respective owners. Where a public forest has its own trained managing personnel, the central service wields advisory and paternal restrictive powers.

So far as concerns the business side of the State Forests, the central service and its organization is quite efficient, not only as regards financial matters and commercial affairs, but technical management in every aspect. In addition to the activities in which the U. S. Forest Service engages here in America, the Swedish service is concerned in many localities with harvesting the crop, transporting it a greater or less portion of the distance to the sawmill, and even with milling the logs and selling the sawn product. All this field of action stands at marked contrast to the U. S. method of selling the crop on the stump and merely supervising the cut and scaling the logs. Marketing the partially manufactured products of the forest is not always an easy job when trade conditions are poor and private producers have glutted the market. The establishment of a special bureau of marketing in the Domain Commission to sell all the products of the state and associated forests and forest industries, was determined upon in 1925. The operation and administration of all property and business under the Domain Commission is above reproach, so far as a critical study reveals. In fact, it is characteristic of governmental activities almost without exception, that they are on at least as high a plane of efficiency as similar private enterprises in Sweden.

For administrative purposes, all Sweden is divided into thirteen districts; each under a responsible executive, corresponding to the district forester in the U. S. Forest Service. Each district forester has a trained assistant and sufficient personnel to care for ordinary duties and business of his district.

The salaried or trained employees in the Swedish Forest Service are divided into two classes; the "ordinarie" personnel and the "extra-ordinarie." The former are on a rather permanent basis as to location and assignment, while the latter may be transferred on short notice and are often idle and unpaid for considerable periods annually. Table VIII, showing the salaried list of the central Forest Service, gives an idea of the duties and organization, as well as the intensity appertaining to public forest management and law-enforcement; exclusive of the administrative overhead in the Domain Commission Office at Stockholm. A comparison is given between the years 1921 and 1923 to illustrate the businesslike conduct of affairs. It is especially notable that in spite of unparalleled pressure from idle trained foresters and their friends, the number of employees in the Forest Service actually decreased.

TABLE VIII.—Salaried List of Swedish Forest Service Exclusive of Central Office Staff [26–107]

Official Title	Number of Employees			
	1921		1923	
	Regular	Extra	Regular	Extra
District Foresters	13		13	
River-driving Engineer	1		1	
Asst. River-driving Engineer		1		1
Foresters	133	2	131	2
Forest Assistants		62		54
Forest School Instructors	9		8	
Inferior Instructors		8		7
Forest Engineers	11		11	
Forest Assessors (Cruisers)	12		12	
Asst. Dist. Foresters	13		13	
Forest Legal Advisors		11		6
Forest Prosecutors (Skogsrättare)	8	7	8	4
Crown Rangers	629	136	627	102
Forest Inspectors	27	9	27	4
Forest Guards		57		174*
Dist. Forest Office Assistants	13		6	
Totals	869	293	857	354

* All forest guards served on a part time basis during 1923; as was also true of 98 administrative assistants employed but not shown in the table.

The greatest technical problem confronting the administration of the state forest areas is the determination of the permissible annual cut from standpoint of sustained yield management. On the forests in the northern part of the country there are yet considerable areas of virgin over-mature and often deteriorating timber. The forest service is concerned with cutting this old stuff as rapidly as possible in order to avoid the losses due to windfall and decay, but its harvest must also be prolonged so that younger stands present, or secured after lumbering, may at least reach small merchantable size before all the old growth is gone. This is essentially the same problem confronting the U. S. Forest Service on nearly all our Rocky Mountain and Pacific Coast areas. Private forestry in central and northern Sweden, by which is meant the big utilization operators, have tried to solve their similar difficulty by purchasing all adjoining forested areas, or at the south where this is impossible, by getting a large proportion of their annual requirements from thinnings and intermediate cutting of other kinds.

The state forest management adopted the latter course wherever possible with reference to their sustained yield calculations; but it is often necessary to withhold the ax from stands that show absolutely no net increment. Very carefully executed surveys, inventories and growth studies have been made on all the state-owned forest areas, so the cutting is never ill-advised. Waste and deforested areas have been investigated and classified with respect to productive capacity and afforestation possibilities. The best sites have been taken up first and a consistent, extensive seeding and planting program has been under way ever since 1880. In this way, and by increasing increment thru drainage, it has become possible to justify much higher cuts of the hyper-mature stock than would otherwise have been the case.

The utilization activities of the state in public forest management stands in sharp contrast to American policy in general, yet it is obviously the part of wisdom, in undeveloped regions where there is no real competition among bidders for stumpage or logs. In fact, it is often found even in localities with well established utilization industries that the private concerns have rather definite understandings among themselves as to maximum prices they will pay for raw material. This sort of agreement in restraint of trade is often tacit instead of formal and not capable of legal contravention. It is always the tendency of such secret and implied agreements to fix prices at such a low level, that their own profits on a very satisfactory basis are guaranteed, regardless of the question of efficiency. On the theory that the government can afford to give its citizens the benefit of every doubt there is a special tendency to make low bids upon anything the government has to sell that requires further fabrication. The elimination of stumpage sales is justified on many areas by reason of the careful methods of cutting which the state uses, but which would be very difficult to enforce with private loggers.

In 1923 the Swedish Forest Service owned, operated or milled their logs on thirty-three different sawmills, located in nine of the state forest districts [66–x8]. The amount sawn was 673,000 logs, yielding squared lumber and ties totalling 3,811,329 cu. ft. The corresponding yearly average sawing between 1916 and 1920 was 359,175 logs [45–105].

In some cases of state sawmilling, plants are leased from their private owners, or practically conscripted, and operated by the forest service. In others, logs were merely custom-sawed by the private mills. With exception of one or two large operations with a view to relieving unemployment in certain localities, all the larger scale sawing of the government is by state-owned and operated mills. However, the total quantity of timber from the State Forests which is sawn before it is sold, is comparatively small as compared to the stumpage disposed of and other forms of wood sold. In 1923 the volume of timber sawn was only about 3% of the stumpage sold.

The great value of the state utilization policy, apparently, is its service as a threat or club, to compel private purchasers to keep their bids on a plane of equity to the seller and themselves. It might be well for the stumpage prices of timber on our U. S. National Forests if a similar policy prevailed there. It is not conducive to a heightened public opinion of government forestry, when public owned stumpage sells for less than half the current price paid for adjacent private timber; in spite of the absence of carrying charges on the former. Timber should sell for its actual value, otherwise it would seem wise to hold it until such time as privately held supplies are exhausted; or in case of rapid deterioration, salvage operations by the government would be preferable to unbusiness-like sales that will sooner or later have a demoralizing effect.

The present tendency in Sweden is to decrease the stumpage sales, at least relatively, while more and more wood is taken out of the forest and more or less worked up under the supervision of the forest administrative personnel. This tendency has been very marked on state forests during recent years in central and south Sweden, but it is not so noticeable in the north. The cutting of material from thinnings and other improvement projects has been on the increase and is rarely on a stumpage basis. The yield from this work is of relatively low quality. Much is charcoaled on the ground and hauled out on sleds to shipping points in winter. Spruce is also sold for pulp and birch as fuel. Wherever ties and mine-timbers can be made at greater profit, they are produced and marketed. The production of all these commodities under the state administration has increased far more rapidly than their sawing of lumber even within the last decade [26–193].

Table IX gives an idea of the increasing relative and absolute yield from State Forest Land during the period of rational management.

The remarkable and nearly uniform increase in annual cutting thruout the country, but especially in the south, is a striking proof of the worth of rational forestry; for it must be remembered that nearly all the State Forest areas in the latter locality were considered relatively understocked, abused, run-down and unproductive. Yet even here, while the cut has been increasing, the growing stock slowly and steadily accumulated until today these State Forests show the

TABLE IX.—Average Annual Cut from Swedish State Forests, 1871–1920

Years	Upper Norrland		Lower Norrland and Dalarna		South Sweden		All Sweden	
	Total Cut (1,000 cu. ft.)	Per Acre per Year (cu. ft.)	Total Cut (1,000 cu. ft.)	Per Acre per Year (cu. ft.)	Total Cut (1,000 cu. ft.)	Per Acre per Year (cu. ft.)	Total Cut (1,000 cu. ft.)	Per Acre per Year (cu. ft.)
1871–1875	63,460	5.43	28,076	10.86	12,396	5.57	103,932	6.29
1876–1880	77,165	5.43	34,151	11.44	13,420	7.44	124,736	6.58
1881–1885	115,132	6.86	35,316	11.00	16,210	6.72	166,658	7.44
1886–1890	120,144	6.15	44,674	10.44	16,281	6.01	181,099	6.86
1891–1895	145,853	5.43	42,485	7.15	25,958	9.01	214,296	7.15
1896–1900	228,353	8.72	96,625	14.01	34,151	9.87	359,129	9.73
1901–1905	186,222	7.44	92,068	13.44	47,818	11.87	326,108	9.01
1906–1910	232,733	7.15	137,661	18.88	70,702	17.02	441,096	10.01
1911–1915	365,375	10.73	189,013	24.88	120,248	25.74	674,636	14.59
1916–1920	418,670	11.73	191,796	25.02	149,138	31.75	760,604	15.87

best stocking of all; as is seen in Table X, where comparative figures set forth conditions by forest districts.

TABLE X.—AVERAGE GROWING STOCK PER ACRE OF PRODUCTIVE STATE FOREST LAND [26–181]

District and Locality	Average Stand per Acre (cu. ft.)
Upper Norrbotten District*	
Interior Region	329
Coastal Region	572
Lower Norrbotten	
Interior Region	515
Coast Region	672
Skelleftea Dist.	
Interior Region	601
Coast Region	672
Umeo Dist.	
Interior Region	701
Coast Region	672
Hernosand Dist.	758
Central Norrland Dist.	1030
Gefle-Dala (old) Dist.	815
Southern Sweden	1387

* Norrbotten is the most northerly Province of Norrland, as all North Sweden is called.

The higher growing stocks prevailing on the state forests of the south is not at all due to higher age-class conditions, as will be seen from Table XI, which gives the comparative average age-classes found on the productive forest soils.

TABLE XI.—AGE CLASSES ON SWEDISH STATE FORESTS

	Norrland and Dalarna*	South Sweden
Blank or Fallow Areas	2%	7%
1 to 50 yrs.	18	61
51 to 100 yrs.	21	26
101 to 150 yrs.	16	6
151 and over	43	
	100%	100%

* Dalarna is the collective name of the rich Central Provinces of Sweden.

COMMUNAL FORESTS

The strictly common areas are of two sorts; county forests and parish or local communal forests (see Table III). Both types of forests in general arose as the natural result of land settlement and development. A map of Sweden having the area and location of these lands, shows that nearly all the important tracts lie adjacent to the boundary lines of the respective parishes or counties upon the poorest and most inaccessible sites from the standpoint of agricultural use. When the various communities became rather stable, apparently the forests about them, that were unclaimed by individual citizens, were set aside as communal property and definitely delimited by the establishment of boundary lines in agreement with adjacent communities. In this way these worthless areas of no-man's land had their titles quieted and became common property of definite villages or the landholders in localities that had become organized into political units. For many years they had little or no value as a source of monetary revenue. They served as common grazing lands under the " Fäbod " and other systems, as hunting grounds, also as an area from which any citizen might take such fuel and other wood as he required, without let or hindrance.

The above described conditions could not survive in an age of commercialism [51–67]. As soon as standing timber began to have a money value, or even when its conversion to a marketable product enabled the more ambitious and aggressive part-owners to merely trade their labor for other commodities, these forests began to be abused. About 1800, conditions were especially bad. All the owners and claimants strove, each in his way, to get as much as possible from the common forests, which were often wrecked or badly injured by ill-advised and haphazard cutting.

The present prevalent status of communal forests stands at marked contrast to the foregoing statements. They are now for the most part models of good forest management and productivity, even if methods of administration and the policy of the owners is rather variable in different localities.

Many of these forests are cut very conservatively. An example to the point is the Jonaker County Forest, which is famous for the heaviest stand of mixt pine and spruce in Europe. The so-called " Savings " forest (besparingsskog), is the result of an opposite policy, at least on the part of the past management. From these areas the mature timber was usually sold as rapidly as the lumber industry could absorb it, and the net income was constituted a fund whose interest and principal belongs to the community and is permitted to accumulate or used as the citizens see fit. Since the forest is " the goose that layed the golden egg," it is very highly considered and well cared for. This type of communal forest is of quite recent origin and limited to north and north-central Sweden. The best known are those of Orsa and Elvdalens parishes.

The county forests have been slowly added to by purchase in many localities during recent years, since wise and just management has displayed the many advantages of such property [26–166a]. The total area of this type of communal forest, its distribution by provinces and growth conditions in 1923, are shown in Table XII.

In 1923 there were fifty-seven Swedish counties that owned land for forestry purposes. The purchase of lands began about 1870, and by 1923 an area of 31,172 acres had been acquired. Since about 1920 purchase has nearly ceased, due to uncertainty as to the legal status of ownership. This question has not yet been definitely adjudicated. These properties were originally considered as being owned by the old land-holding citizens and families of each county, and hence subject to their disposal. The present status of the county as a political or social unit, gives rise to the claim that these forests are equally the property of newcomers as of old resident families. With modern industrial development and shifting of population, many counties hesitate to economize or tax themselves for the benefit of a host of outsiders, who may move in and be considerable gainers without equivalent sacrifice.*

TABLE XII.—Area and Character of County Forests
(Acres)

Province	Productive Soil			Waste Land	Total Area
	Forested	Blank	Cleared		
Kopparberg	14,115	1,095	12	6,091	21,313
Örebro	20,751	2,115	509	4,924	28,299
Vestmanland	22,648	2,627	1,079	5,816	32,170
Uppsala	34,357	2,354	617	9,916	47,244
Stockholm	5,466	405	212	1,258	7,341
Södermanland	40,986	1,475	624	15,463	58,548
Östergötland	51,608	3,481	2,669	14,549	72,307
Skaraborg	13,137	456	427	4,216	18,236
Elvsborg	3,831	155	101	1,643	5,730
Jönköping	2,714	84		277	3,075
Kalmar	818	51	139	35	1,043
Totals	210,431	14,298	6,389	64,188	295,306*

* Figures vary somewhat according to authority followed, hence totals here are not exactly in agreement with those elsewhere stated.

The conservative character of management on most county forests is notable, as illustrated by example and facts below stated [26–166]:

The forest of Kinda in Östergötland had originally only 881 acres area, but it was decided that its net income should be expended for acquisition of additional land, so that in course of forty years 4,444 acres were added. All of this area was well stocked except a small part which was immediately planted up.

The growing stock on all the county forests totals 423,800,000 cu. ft., which is an average stand of 1,872 cu. ft. per acre of productive forest. It must be admitted, however, that the forests in this type of ownership are well located from standpoint of prevalent soil and climate, hence should exhibit good growing stock conditions. Yet they are probably surpassed in these respects by the Church Forests in the same provinces, but the stock on these latter lands is only 1,401 cu. ft. per productive acre as an average. In 1915, investigations showed that the average volume of growing-stock on productive soils of the State Forests of South and Central Sweden was only 915 cu. ft. The average volumes for the several age-classes of the county forests are given in Table XIII.

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* The central government is also held by many to be the owner of most county forest lands [59–6/1/1929–315]; the county being merely possessor of the right to use or harvest their products.

TABLE XIII.—COUNTY FORESTS; AGE CLASSES AND AVERAGE ACTUAL PER ACRE GROWING STOCK VOLUMES

Age-Classes	Volume (cu. ft.)	Age-Classes	Volume (cu.ft.)
1–20 yrs.	100	61– 80 yrs.	2,503
21–40 yrs.	987	81–100 yrs.	3,146
41–60 yrs.	1859	101–120 yrs.	3,360

The Jönoker Forest has a limited area with a growing-stock of nearly 14,500 cu. ft. per acre. Some other counties own small areas of practically undisturbed virgin forest with very heavy stocking.

Assuming a rotation of 100 years and a five-year regeneration period, the normal and actual age-gradation conditions compare as given in Table XIV, for productive forest area only.

TABLE XIV.—AGE-GRADATION ON SWEDISH COUNTY FORESTS

Age Classes	Normal Area (acres)	Actual Area (acres)
Forest 1–20 yrs. old	43,208	37,742
Forest 21–40 yrs. old	43,208	39,847
Forest 41–60 yrs. old	43,208	29,143
Forest 61–80 yrs. old	43,208	20,645
Forest 81–100 yrs. old	43,208	27,240
Forest 101 yrs. of age and older		55,738
Blanks	8,635	14,320
Totals	224,675	224,675

The productivity of these county forest areas is given in Table XV; according to an adaptation of Prof. Tor Jonson's site quality classification which is based upon the best possible rotations and silvicultural practices in respect to volume production. It is seen in

TABLE XV.—SITE CLASSIFICATION AND POSSIBLE YIELD OF SWEDISH COUNTY FORESTS

Site Classes	M. A. I. per Acre Average (cu. ft.)	Areas in Each Class (%)
I and II	132	0.6
III and IV	75	60.4
V and VI	42	34.1
VII and VIII	21	4.9
		100%

this table, that an inconsiderable area lies in the very best site classes, as is natural when we remember that most of the areas have been subject for centuries to clearing and temporary or permanent cultivation, depending upon their native fertility. The areas unsuited to permanent agriculture reverted to forest again, but those capable of good crop yields are today cleared and leased by the counties or have been sold to private owners.

The disposition of the wood yield from this type of communal forest is well discussed by Prof. J. A. Amilon [64–6 and 24/1925–205X], who is the best authority upon the status of these Swedish forests in every respect.

The old original landowners and certain of the lessee residents in the counties may be considered as shareholders in the corporation or county, which received title to these forests, or has since purchased them. This share or part-ownership right appertains to the various homesteads in each county. It has often been subdivided in course of past years as land has been sold and assigned, yet the shareholders are carefully registered in practically every case, and ownership appertains quite closely to those lands in use for farming. The industrial worker and similar residents are not generally considered to have acquired rights in these county lands, even tho they own their homes therein. On the basis of this sort of ownership, it is easy to understand why originally practically all the yield from these lands was apportioned in kind. This method of disposing of the crop still prevails in many places. At times each part owner is allotted the right to cut certain standing trees. More commonly a definite value or quantity of felled and hewn or split and piled wood is granted each shareholder. But in nearly every case enough wood and timber must be sold to pay for the administration and management of the forest. It is often inconvenient to many owners to accept or get their dividend in kind, so there has been a constant tendency in later years toward selling all the wood yield and declaring money dividends. In many cases the money yield has also been funded until a real worth-while "melon could be cut." The yield is often reinvested to pay for silviculture and other improvement work, or expended for purchase of additional land.

The foregoing discussion has been rather more detailed than may be thought needful, but it gives much information that is more or less applicable to the parish and town communal forests, or even the church forests.

The two first-mentioned types of ownership are truly communal in nature. Their total area (see Table III) is over 1,130,000 acres of productive forest. All are managed under working plans either promulgated or approved by the central Forest Service. They fall into two classes, however, as to administration [66–73]. Many are managed directly by the Forest Service staff along with the state forests of the locality. Others have their own administrative officers, responsible to the parish and town officials, but subject to being checked and controlled by the Forest Service. This is the status of most large properties of this kind under discussion. The Orsa and Elvdalen Savings-forests are examples to the point. Most of these parish forests have been established by law or royal proclamation [26–183], and given therein are certain fundamental prescriptions for their management.

The below résumé for these two famous Sweden parish forests will give some idea of the big business and technical problems that must be solved in handling some of these communal areas in the best interest of both present and future owners.

TABLE XVI.—Résumé of Elvdalen and Orsa Parish Forests

Productive Areas (acres)	Elvdalen	Orsa
Forested	104,923 A.	122,207 A.
Blank	877	9,593
	105,800	131,800
Waste Areas		
Bog Land	27,163	31,972
Lakes and Streams	3,589	8,943
Rocks, etc.	229	236
	30,981	41,151
	136,781	172,951
Site qualities and M. A. I. per acre in % of total productive areas.		
III—possible yield, 85 cu. ft.		1%
IV—possible yield, 64 cu. ft.	12%	1
V—possible yield, 49 cu. ft.	14	40
VI—possible yield, 36 cu. ft.	54	48.3
VII—possible yield, 26 cu. ft.	17	9.7
VIII—possible yield, 17 cu. ft.	3	
	100%	100%
Age-Classes in percent of total productive areas		
Blanks	.83%	7.3%
1–40 yrs.	21.59	12.4
41–80 yrs.	18.80	12.7
81–120 yrs.	17.47	10.9
121–160 yrs.	16.88	29.4
161 yrs. and older	24.43	27.3
	100%	100%
Growing Stock by *Volume*		
Thrifty Growing Stands	31,000,000 cu. ft.	18,000,000 cu. ft.
Mature Stock	19,000,000 cu. ft.	49,000,000 cu. ft.
Hypermature Stock	17,000,000 cu. ft.	61,000,000 cu. ft.
Total coniferous G. S.	67,000,000 cu. ft.	128,000,000 cu. ft.
Hardwoods		2,460,000 cu. ft.
Dead Stand Timber	3,970,000 cu. ft.	6,320,000 cu. ft.
Scattered Timber on Waste-land		5,660,000 cu. ft.
Grand Totals	70,970,000 cu. ft.	142,440,000 cu. ft.

Growing Stock Classes in percent of total Volume and number of trees

	Elvdalen	Orsa
Thrifty Growing Stands	39.3% and 56.8%	30.19% and 14. %
Mature Stock	32.1 and 20.9	30.6 and 38.4
Hypermature Stock	28.6 and 22.3	39.21 and 47.6

Volume Increment by G. S. Classes

Thrifty Growing Stands	2.49%	2.49%
Mature Stock	1.06	1.01
Hypermature Stock	.69	.72
Average for Each Forest	1.52%	1.08%

Annual Expenses for Maintenance and Improvements

	Total	and per Acre	Total	and per Acre
Land Drainage	$3,283	$.031	$6,042	$.046
Assistance Cuttings	1,305	.012		
Direct Seeding and Planting	857	.007		
Forest Roads	9,215	.088	2,820	.021
Cabins and Camps	1,935	.019	1,265	.010
Totals	$16,595	$1.57	$10,127	$.077

These forests are located in a region of extreme cold winters and quite warm summers. The soil is not especially fertile, and it will be noted from Table XVI that increment is low on the average. The expenditures for silviculture and improvement of the forest are not high, even when compared to American standards. The salient fact that we should note in connection with these forests, and most all others in Sweden, is that they yield a real net revenue, in spite of all adverse conditions. To manage our own woodlands that way, while gradually working toward a normal age-class and growing stock basis should be the object of every American administrative forester.

The two parishes above dealt with are considered rich and escape all local taxation, due to the income from their forest properties. Moreover, substantial funds have been built up and put these communities in excellent position for the traditional "rainy day."

The general disposition of incomes from the parish and city forests is illustrated by the following quotation from the basic law establishing the Orsa Parish-forest: "The income from accumulated funds, as well as the yield of the forest, shall be disposed of by the land owners of the parish with the approval of the provincial government as provided by the basic law. The administration, protection and reproduction of the forest shall be first provided for; thereafter the incomes shall be devoted to ends that are in general necessary or beneficial to the community, such as medical or hospital service, poor relief, public education, improvement of agriculture by drainage or other projects, housing improvement, establishment of new and improvement of old roads."

The Church forests are, in general, of better than average quality for the regions in which they are located. They are often definite areas set aside to provide for the salary and expenses of the parish pastor and other church officials. At times the incomes go into ordinary or special church funds, being accumulated for general or definite purposes. These forests are sometimes managed on very charitable lines and, as a rule, are not so well cared for as other public forests. Administration is directly under the Forest Service, but restrictions often prevent most efficient handling of the areas.

OTHER PUBLIC FOREST LAND

The Reindeer-grazing Lands have a total area in excess of 2,500,000 acres, and include 407,375 acres of productive forest. They are essentially communal property held in ward by the state for the benefit of a more or less dependent people, the Lapps. They have therefore certain features in common with our Indian Lands in U. S., and market conditions are what can be expected for a regional high elevation and the inaccessible interior of the far north [66–x45]. All details of management are in the hands of the central Forest Service. Net incomes are not always realized, altho most years show the balance on the right side of the ledger. The 1923 gross income was $42,967.35, with a net of $13,089.65, but the preceding year showed a deficit of $1,889.31 on a slightly greater gross income.

The major problem on these areas is the control or regulations of the grazing so as to prevent the injury of the forest stands and consequent lowering of the upper limit of tree growth. The stolid and backward Lapp even begins to react to the commercial spirit of the age in some localities, so that trading and speculating in reindeer, as well as increased breeding herds, bring about conditions that threaten the existence of the meager forests. The regulations and educational measures in vogue remind one somewhat of the difficulties and dangers grazing means on some U. S. National Forests.

The Lapp has not usually been a conservationist, and often gets his large requirement of fuel-wood in very destructive and otherwise ill-advised ways. The work of education in general and imparting a knowledge of the importance of better treatment of tree-growth go hand in hand, and are making substantial progress.

CHAPTER III

FORESTS VERSUS FARMING

General agriculture in a land so far north as Sweden naturally suffers under certain handicaps that are inherent. The climate limits the choice of crops and magnitude of yields. Glaciation usually mixes the original rocks and grinds or scores them so that the soils are fundamentally fertile, but it also sorts the materials and heaps up many irregular moraines, so that most sites are too rocky or present such broken topography and poor drainage conditions that cultivation is seriously hindered. In recent decades a world market has developed in respect to most foodstuffs, and Swedish farmers felt more and more the pressure of competition with food producers on America's fertile prairies and the far-flung plains of Russia, Australia and the Argentine. As compared to vast sandy tracts under cultivation on the North German plain and elsewhere in Central or South Europe, Swedish farmlands generally are far superior. Much fertile land has been won thru artificial drainage and natural silting up of shallow lakes. The farmers have also adopted the most modern machinery conditions permit them to use, and by invoking a protective tariff, prevented a more rapid retrogression, yet in many respects the people are extremely conservative. An example to the point is in regard to celery. This vegetable is very little grown and ranks as a luxury in spite of the very favorable sites it would find in the deep humus of the numerous drained marshes. This state of affairs is more to be deprecated because the consumption of more vegetables with high vitamin and mineral content would certainly improve the general health. The tariff policy also reduces consumption of apples and other fruits which can, during favorable seasons, be produced in Sweden. This reduction, however, may only serve to increase consumption of other kinds of fruit. It is also notable that small fruits are abundant and of high quality usually, even if apples are wretched in form and flavor. Wild berries from the forest are of considerable importance, especially the dwarf or European Cranberry (*Vaccinium vitisidæa*).

The above facts, coupled with the industrial revolution of the last century, brought about the abandonment of considerable areas of cleared but marginally productive land. These have since been largely reforested by nature or man and are now supporting very productive stands, or else they form part of the low grade pastures which would be socially more productive if growing a timber crop.

CLEARING BY FIRE,—("SVEJNING")

A long while earlier, in fact before the year 1600 [51–36], Finnish settlers in North Central Sweden started a practice which still has some vogue and probably was not unknown before that time. Scandinavian economists and foresters refer to it as the " Finnish Use " of land. It consists merely in the practice of a peripatetic agriculture somewhat similar to that which curses many tropic and sub-tropical lands. The forest on likely areas is cut down and burnt at a time when everything is very dry. The fire usually becomes hot enough to consume nearly all the accumulated vegetable débris and leaves a bare and easily cultivable site. The Finns and their neighbors at that early date and later made little effort to cultivate most of these burnt areas, but instead only pastured them, and the forest usually was quite prompt in winning back domination again. Many excellent stands of pine originated on the lands treated, or possibly mistreated this way. It is even today advocated by some foresters, who ought to know better, as the best mode to reproduce pine in pure or near-pure stands on soil that tends to go over to spruce or hardwoods, altho ill-adapted to them. This practice in actual effect was a severe and wasteful drain upon the forest resources of many localities. As its practitioners were little better than nomads, the political and financial powers of that time rallied to the defense of the forest and gradually brought the use of fire in this connection into disrepute. The use of fire in clearing for pasturage and the plow has some very influential proponents today. They show that the natural and increasing acidity of the forest soil under coniferous stands in temperate cold climes is neutralized by the ash residues after burning, and this fact, in addition to the liberation of much soluble mineral fertility, accounts for the excellent growth made by crops for a few years after the burning, or also for good seedling growth made by certain species of trees consequent to fire [3–150 to 152 and 74–300]. In all probability, the harm wrought upon the forest by this Finnish method of land cleaning lay mostly in the attendant carelessness with fire. Had the areas burnt been limited to such as were cut off and needed for farming and pasturage the antagonism of the iron working and mining interests might have been avoided, since deterioration of the soil and stands, as well as the gross forest area, would have been very slow. But as the fires started for land clearing frequently devastated considerable territory, the big wood-users naturally became alarmed, and not without cause, for we must remember that all metallurgical interests in Scandinavia were absolutely dependent on charcoal, due to the absence of mineral coal. In this connection there also existed, prior to the invention of explosives, a most insistent demand for wood; one which literally laid waste all forest growth for miles around the ore mines. At that date the only substitute for modern blasting of mineral-bearing rocks was to build huge fires on or beside the rock in question. When the rock face became highly heated the fire was quickly raked away and cold water was dashed over the incandescent surface. The sudden cooling and contraction of the rock substance in combination with the expansive effect of the precedent heat was more or less effective in breaking up even the most refractory. This practice was a very wasteful application of heat, however, and demanded fuel-wood in huge quantities.

From the standpoint of present scientific light, it is doubtful whether even the good pine stands arising after these clearing fires in Sweden, or after any fires anywhere, can be justified or recommended as the best silviculture [3–151 and 152]. The truth of the matter is that a fallow period, or one of grazing and agricultural use practically always intervened before the much-desired and highly-praised coniferous stands established themselves. In other cases, on better soils, there came in a temporary change of species, usually of trees and shrubs, to which an acid soil is rather inimical. It is invariably recorded that on the poorest rocky sites these fires worked real harm or actual disaster, so far as regeneration and productivity of the forest was concerned. With due respect to all labored attempts toward explaining this last fact, it is likely really due to the non-intervention of the "farm pasturage-change of species" stage on these sterile or otherwise adverse sites. All possible supplies of soluble mineral fertility, as well as the electrolytic effect of these solutes, is more needed on such sites than upon better ones, if their direct effect on the conifers concerned was the only factor to be reckoned with. Even the most marked calcofuge species grow well on limestone and other neutral soils, though possibly no better than on equally moist and fertile acid ones. The important factor that tends to exclude nearly all conifers, as well as many other tree species, from such soils are the low fungous organisms that thrive there and damp-off or otherwise destroy practically every seedling of such species before they attain their first season's growth.

The luxuriant development of herbs and broadleaf woody plants that crave neutral to minim-alkaline soils, is also a great hindrance to success of coniferous reproduction for a few years after the areas are burnt off.

The course of events that usually followed land clearing was a more or less brief period of profitable cultivation during the time when soil acidity was nearly or quite neutralized, but as the soluble plant foods and other mineral compounds leached and dwindled away, all crops and grass yields decreased, and surface conditions assumed again their natural acid reaction, especially where considerable humus remained undecomposed or plant residues accumulated. When this acidity, which is quite inimical to the fungi above mentioned, began to assert itself, then the seedlings of pine and spruce established themselves by thousands on every acre of land; the forest resumed again its domination and began to gather and store more and more of plant food, in shape of its slowly decomposing litter, which surface soil acidity steadily increased.

It is ventured that better and quicker coniferous reproduction could be obtained on all areas similar to the ones in question by cultivation so as to mix the upper mineral soil and humus layers, at the same time stimulating decomposition still further through admission of sunlight by judicious cutting.

GRAZING IN SWEDISH FORESTS

The old dairy industry of both Norway and Sweden was more unique than efficient [6]. At least this is the verdict of the agriculturalists and foresters who studied the grazing and related problems in the two countries during recent years [26–122]. The " fäbod " system existed almost from the dawn of civilization here, and was simply forest grazing of milk cows, as a rule. It was carried on only in summer, and without more than a minimum interference with forest conditions. It was typical of the deep, distant and nearly inaccessible mountains.

A log cabin of crude construction, a yard, possibly a shelter for the animals when weather was most inclement, with a few square rods of cleared ground located at an unfailing source of water, describes the physical features of these mountain or woodland dairies. Here the cattle were driven in spring or early summer, so soon as developing vegetation justified it. They were attended and cared for there, usually by some one too young, too old and infirm, or otherwise incapacitated for the hard work at home, of summer haying and crop cultivation. Butter and cheese were the standard products of the institution, and the inaccessibility of the regions where it held forth, and still continues, is attested by the fact that the summer yield could rarely be hauled home or disposed of until after cold weather made sledding over the deep marshes and lakes possible.

There is much romance connected with this dairy system. The long and lonely vigils of women and youths or maids of tender years, which it necessitated, appeal to the thought of the poet and psychologist, but production costs and quality of yield are features of the " fäbod " that make it ineconomic today. Milk and meat animals are too valuable now to subject them to the risks the system entolled, hence it promises to become a matter of history as years pass.

The forest never suffered very greatly from this kind of grazing in general, though in exceptional cases damage to young growth occurred. The greatest injury from grazing in Sweden is found in the neighborhood of scattered human habitations; where the family cow is in evidence, together with miscellaneous young cattle and other stock.

It will be a matter of surprise to hear that vast regions of the countries of north-west Europe are to all intents and purposes without fence-laws. In other words, the pioneer necessity of fencing to keep animals out prevails, instead of the legal requirement that an owner is responsible for damage done by his roving flock [52–87 to 90]. Grazing is in some places the greatest obstacle to rational silviculture and forestry. Many farmers even in Sweden do not yet realize the importance of their woodland nor their productive possibilities when correctly managed. Such owners, and naturally most renting farmers, have a secret inclination to convert all forest land into pasture. The grazing industry is powerful even in old countries. Every proposed law before the Swedish Riksdag that interferes with grazing customs, or threatens to curtail what is commonly a short-sighted abuse or unwise use of land more productive under forest, meets strenuous and successful opposition. Many of the provincial foresters subscribe to the sentiment that the present frequent attempt of farmers to combine grazing and forestry much decreases the yield from both.

The Swedish Pasture and Grazing Association [26–123] has done good educational work and made careful studies, proving the all-around advantage of intensive care and improvement for pasture lands. It supplies advice in general and service of its expert examiners at cost in an effort to increase the acreage of cultured and fenced pastures. The below parallel comparison from this authority shows the gain to both forestry and grazing when rational pasturing replaces the promiscuous customs of the past.

THE RETURN FROM GRAZING

I. Woodlands and uncultivated fields.	II. Well sown and cultured pasture and hay fields.
Per Acre Yields	
20 to 40 fodder units, or 120 to 250 pounds good hay.	400 to 1,200 fodder units, or 2,500 to 7,000 pounds hay.
Grazing Area Required Per Animal	
6 to 25 acres or more.	.6 to 2 acres, and at times less.
Results	
Usually loss and poverty for the stock and forest owner.	Good returns from stock on a smaller area and an important gain thru silviculture, on the rest.

" Careful studies and calculations made in South Sweden set forth the relative advantage of forestry over grazing as given in the below schematic outline [59–1916–39]. This study covered actual results from lands used for the respective purposes for over 100 years. It must be kept in mind, however, that grazing merely means the feeding off of the natural wild grasses that spring up annually. If cultured pastures were compared with forestry, the difference might not be so sharp, or possibly would be reversed.

NET RETURNS PER ACRE FROM GRAZING AND FORESTRY IN TERMS OF MONEY PER YEAR

	Best Soils	*Medium Soils*	*Poor Soils*
Grazing	$.43	$.16	$.05
Forestry	1.62	1.30	.76

The attention of land owners to the necessity for more modern fence laws has been forced by forest laws requiring reforestation after cutting. The obligation of the owner is not discharged by merely cutting or treating his property according to the prescription of the provincial forester, but he must sow or plant up the area if natural reproduction fails, and in case these more expensive measures are fruitless, he must again repeat them with even greater care and cost. Since roaming cattle are the chief cause for imperfect regeneration of the forest and failure of plantations, it is obvious that the larger forest owners insist upon a just restriction of public pasturage. Most of Sweden can be classed as a natural grass country if the soils are fertile and drained, so trouble with grazing is quite general.

In North-central Sweden there are many rather extensive forest properties whose owners have willingly fenced their forest plantations, but often to no avail, due to mischievous or spiteful destruction of the fences if they are not frequently patrolled.

Special privilege dies hard everywhere. It is not alone in conservative Europe that evil, foolish and unjust special rights and customs have become intrenched and rooted so firmly that society cannot eradicate them for years after progressive and enlightened thinkers prove their folly and injustice. Witness the liquor traffic, protective tariff and human slavery in America. The greater the injustice worked by a special interest, just so much more bitterly it fights to maintain itself. With all these facts and examples before them, every forester and every forward looking American citizen should resist all efforts directed toward dismemberment of our National Forest system, or curtailment of the public rights in them. The grazing industry and every other user must be constantly compelled to recognize that our national forests are the fee-simple property of all the people for all time.

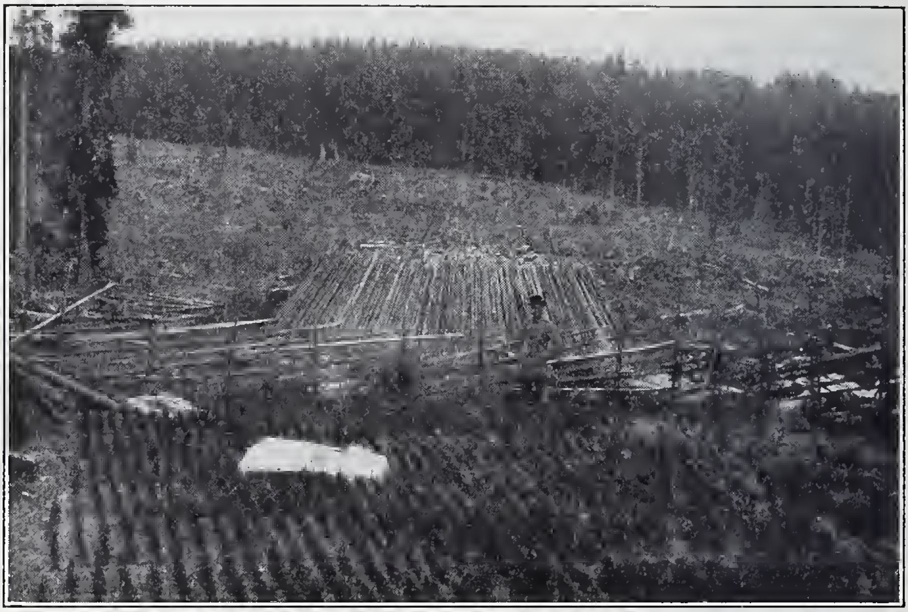

Fig. 2.—Good Forestry on a Farm Woodlot.

Area has been clearcut and all material utilized. Pile of charcoal wood is seen in middle foreground. Trees have been set in transplant nursery for planting up all space not promptly occupied by natural regrowth.

The best ordered and most efficient agriculture in Sweden is found on the large estates in the south and central parts of the land. Their owners and managers are usually well informed and take pride in good livestock feeding on rich pastures, as well as thrifty well kept woodlands. The custom of promiscuous grazing is in general a thing of the past, except where an occasional backward renter persists in the practice from hope for some little and easy present gain, which is actually often more apparent than real in the end, even from his individual standpoint.

The problem of roaming livestock is not so easy of solution in the great forests of the north. These lands are like vast extents of our Rocky Mountain forests, only adapted to growing trees, but even for this purpose requiring rotations well up toward 200 years, or even more, to produce saw timber. Owners of such marginally productive lands cannot afford to fence them, and reproduction without hinder from grazing is often slow and incomplete. Not cattle alone, but horses, sheep and goats graze at large here in considerable numbers. The damage on lands of the large private owners is greater than on communal areas and farm woodlands adjacent because of prevailing silvicultural methods. The former owners generally practice selection forestry by cutting to a diameter limit; while clearing small areas and blocks with or without reserving seed-trees and more or less soil preparation, dominates on lands of the big wood-using corporations and individuals. The first method of cutting encourages ericaceous shrubs and brush, while the second permits decomposition of the accumulated raw-humus and the temporary thrift of grass and herbs. In such a country of cold and moist weather, the latter silviculture yields the greater returns if a stand can be re-established in a reasonable length of time. But livestock concenter their attention where the food is best and hence the better silviculture is penalized. The only gain from grazing in Scandinavian forests is the elimination of birch in inaccessible regions where it is a weed.

With the people of some sections in the north, forest grazing is almost a religion. Otherwise intelligent men will attempt to maintain that "the closer an area is grazed the better the forest reproduction which comes in upon it." It was even proposed when the rent laws were being revised, that land owners be forbidden to deny their lessees the privilege of pasturing all forest land [52–251].

The alluvial soils are those best adapted to agriculture and generally farmed at present on a profitable basis. The Moraine soils are often quite fertile, but not easily worked and subject to leaching or requiring drainage in many instances. After centuries of search and trial by a land-hungry people, it is illogical to believe that any considerable aggregate area of soil of permanently arable quality remains under forest in south and central Sweden.

In the north, economic conditions and the limitation of crops by climate forbid the present extension of cultivation in all but the most favorable localities.

It is probable that nearly every acre of Sweden now in forest, as well as much cleared or partially cleared land, will yield a higher

TABLE XVII.—YIELD TABLE FOR AVERAGE QUALITY SITE, PINE AND SPRUCE, MALINGSBO, CENTRAL SWEDEN [73]
(Constructed under direction of Prof. Tor Jonson)

Age (yrs.)	Av. Ht. (ft.)			Sectional Area (sq. ft.)	Average D.B.H. (in.)		Average Form Class	Volume		Trees per Acre			Av. Volume per Tree (cu. ft.)	Value ($)			
														per cu. ft.			per Acre
	Pine	Spruce	Pine and Spruce		Pine	Spruce		Per Acre Total (cu. ft.)	Pine,—% of total	Pine	Spruce	Total		Pine	Spruce	Pine and Spruce	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
20	20	14	18	41	1.8	1.4	0.62	429	75	1820	1210	3030	.14	.013	.006	.012	5.17
30	29	21	27	63	3.4	2.6	0.63	887	73	705	570	1275	.81	.038	.03	.034	30.45
40	36	28	34	76	5.	3.9	0.64	1401	71	400	320	720	1.94	.05	.042	.047	66.63
50	44	34	43	87	6.4	4.8	0.65	1873	69	260	255	515	3.6	.062	.051	.058	109.83
60	50	39	48	96	7.6	5.6	0.65	2302	67	198	222	420	5.47	.073	.058	.068	156.92
70	56	45	53	101	8.6	6.2	0.65	2674	69	170	178	348	7.66	.083	.064	.078	207.14
80	59	49	57	107	9.6	6.8	0.66	3003	71	150	141	291	10.06	.093	.07	.086	258.87
90	63	53	60	110	10.4	7.3	0.66	3274	73	134	117	251	12.82	.102	.075	.095	310.07
100	67	57	63	112	11.3	7.9	0.66	3489	75	122	97	219	15.93	.111	.08	.103	359.92
110	69	60	65	114	12.	8.4	0.66	3645	77	113	77	190	19.17	.119	.085	.111	404.78
120	72	63	66	116	12.8	8.8	0.66	3745	79	105	65	170	22.78	.127	.088	.119	445.39

TABLE XVII.—YIELD TABLE FOR AVERAGE QUALITY SITE, PINE AND SPRUCE, MALINGSBO, CENTRAL SWEDEN [73] *(Continued)*
(Constructed under direction of Prof. Tor Jonson)

Thinnings during foregoing 10 yrs.						Thinnings in % of total Production by:		Current Annual Increment				Total Production per acre		Total Av. Production per yr. per Acre		Average Value of Yield per cu. ft. ($)	Age (yrs.)
Trees per Acre	Volume (cu. ft.)		Thinning percent	Value ($)				in Volume per acre		in Value per acre							
	per Acre	per Tree		per cu. foot	per Acre	Vol.	Value	cu. ft.	%	$	%	cu. ft.	$	cu. ft.	$		
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
								43	10.	1.84	36.2	429	5.17	21	.26	.012	20
1755	128	.07	19.	.006	.76	12.6	2.4	66	7.4	3.40	11.1	1015	30.76	34	1.02	.030	30
555	214	.39	17.5	.026	5.72	19.6	8.9	77	5.5	4.91	7.4	1743	73.11	44	1.83	.042	40
205	314	1.48	17.5	.043	13.50	26.	15.4	80	4.3	6.26	5.7	2529	129.87	50	2.60	.051	50
95	357	3.16	16.	.056	19.98	30.6	20.3	77	3.3	7.24	4.6	3315	196.88	55	3.28	.060	60
72	386	5.01	14.5	.066	25.49	34.5	24.	73	2.7	7.88	3.8	4073	272.59	58	3.89	.067	70
57	386	7.06	13.	.076	29.16	37.4	26.8	69	2.3	8.26	3.2	4788	353.48	60	4.42	.074	80
40	386	9.35	11.5	.084	32.40	40.	29.1	63	1.9	8.42	2.7	5445	437.08	60	4.86	.080	90
32	386	11.72	10.5	.091	35.32	42.2	31.2	57	1.6	8.42	2.3	6046	521.74	60	5.22	.086	100
29	386	14.34	10.	.099	38.23	44.7	33.1	51	1.4	8.26	2.0	6588	605.33	60	5.50	.090	110
20	386	17.13	10.	.106	40.82	47.	35.1	46	1.2	7.96	1.8	7074	686.76	59	5.72	.097	120

Species = 70% to 80% Scotch Pine, the rest Norway Spruce.
Crown Density = .8 to .9
Thinning Method = Medium heavy rational cutting favoring spruce at first, later pine.
Regeneration Method = Clear cutting with Scattered Seed-trees and sowing in prepared spots.
Calculation of Stumpage Values is based on prevalent labor rates in 1917 and 1918, (about 19c per hour) and the below wood prices at the mill or place of use:—
Charcoal = 16c per bu.   Pulpwood = 16c per cu. ft. scaling sticks in middle.
Timber = 19c, 21c, 24c and 28c per cu. ft. respectively for logs 6″, 8″, 10″ and 12″ or more in diameter at small end and based on scaling there to nearest falling ½″.
Cost of River-driving = 8c per whole bole, 3c per 11′ to 14′ log and 1⅔c per shorter log.

monetary return under forestry than agriculture. The development of the pulp industry and charcoaling render the income fairly certain and steady,—permitting close utilization at a profit. The only excuses for clearing are hope of a quicker return from capital invested in the land and the desire to avoid the requirements of reforesting all cut-over land not to be used for cultivation or pasture.

PRIVATE FORESTRY AND FINANCIAL RETURNS

In nearly every land forestry is more remunerative and economically advantageous when combined with some other line of activity. It also tends to make all the fields of human endeavor more profitable than would be the case if each were independent. The only marked exception to the above generalization is grazing. General agriculture and forestry are highly compatible because of their respective seasons of maximum activity and labor requirements. In Sweden, as elsewhere, cutting is chiefly done in winter, and the dull seasons on the farm coincide with the period of harvest in the forest. It has also been shown that rational forest management is most advantageously practiced by the industries [52–169] that use wood as a raw material. The control of large bodies of stumpage is a fixed policy with many big wood users in America, but the number who are far-sighted enough to grow their own is woefully few. This cannot be said to be true in Scandinavia. There nearly every corporation and individual in the saw-milling, paper-pulp or iron business realizes that the forest is the source of their prosperity and capable of being renewed and stimulated to higher production on one hand, or devastated and destroyed on the other.

The actual income per acre from forestry in Sweden is equal to or greater than that from agriculture, if carefully collected and tabulated statistics mean anything. But in neither case, when average incomes are considered, is the rate of net yield very high after deductions or charges to cover labor incomes are made. Because of the less labor involved, forestry often shows better returns than agriculture. This fact is realized by many land owners, but due to the annual return from grazing and other less suited uses, these are sometimes preferred to forestry, where much capital would have to remain tied up for years with a yield of relatively little income.

The money yield-table herewith published, with conversions into units of measure and value common to American forestry, gives a broad idea of what possibilities good practices and business methods show in the forests of Central Sweden. It is true that values in this table may be slightly roseate, and that wages have risen and wood prices fallen or remained nearly stationary since it was constructed, yet it is still a good general catalog of yields against which we may measure or compare the results, prices and prospects of forestry and forest production in our own land.

It is futile to make studies showing the yield in percent upon the money invested in forest properties. This investment is in part for land and permanent improvements, and the rest is represented in the growing-stock. It is a universal law of economics that land values are a sort of differential quantity, rising or falling in accord with the net productivity of the enterprises to which they are adapted or used. Labor must first be paid and capital receive the rate of return which will put the enterprise on a paying basis comparable to other fields involving an equal risk. Any yield above the amount needed to meet the foregoing requirements, if not required for payment of taxes, is capitalized at the usual rate demanded for money in the locality to establish a value for the land in question. To contrast the forestry of different lands from a financial standpoint, it is therefore only necessary to compare prevalent interest rates and forest land prices when sales are made in the open market. In applying the foregoing rule, it should be borne in mind that the recompense to labor includes the reward demanded by the entrepreneur or manager, also that forestry is primarily a land investment and hence possessed of certain elements of safety which may cause owners of capital to be satisfied with slightly lower rate of return than they require of other enterprises where their funds are sunk in less tangible and permanent or more easily embezzled forms of property.

The prevalent money interest rate is more or less completely dependent upon the interplay of the laws of supply and demand. By virtue of civilization, culture and the enforced development of an instinct to save, there is a constant tendency for interest rates to decrease in all lands. This tendency is checked and counteracted by wars, public calamities and like eventualities. The psychology of a people is also a factor to be reckoned with. The pioneer mind,—willing to take a chance but demanding high stakes in return, helps to maintain prevailing rates at a higher level.

From the preceding discussion we may deduce a strong reason for the government ownership of forest lands, also why it is wise policy for a corporation with long future prospects to invest in lands of value for forestry or other purposes.

Sweden shows interest rates about on a par with those prevailing in the Middle-western U. S. The population is not so thrifty as that of Holland, France or Germany. Real estate incomes of 5% or more were the rule, even prior to the World War. Since then, rates have been gradually decreasing to the original plane from a much higher one attained during that hectic period.

The values derived from forest production in Table XVIII are not on a basis suited for comparison with the figures for cultivated land, since areal units considered are different and most of the forestry returns were achieved prior to the War. It is safe to say that forest lands of average quality in the regions considered have productive values 50% higher than given in the table. From Table VI can be deduced the prices paid by the government for forest lands in several provinces during 1923. From this it appears that market values varied roughly, between North and South Sweden, from $8.00 to $70.00 per acre, and averaged $43.94. These prices may not exactly represent the productive possibilities of the soil for a forest crop in many cases. Lands are often bought for administrative reasons. It is also quite certain that the forest land purchased would be somewhat higher in quality and basic productive capacity, in nearly every locality, than the average for state forests thereabouts. The prices paid for land are also to a limited extent an effort to evaluate future yields, especially when long-term investors, such as corporations and the government, are concerned. These are the only considerable purchasers of forest land, but in many localities there is a ready demand for lands adapted to or already used for timber growing. The larger wood-using concerns are anxious to make secure the permanence of their investment and output as a general thing. To do this, they buy up all suitably located areas.

TABLE XVIII.—LAND VALUES IN SWEDEN BASED ON CAPITALIZATION OF NET RENTAL AT 5%

	Value per Acre
Farms in Central Sweden (1923)*	
Large Estates	$55.08
Average Farms	68.04
Small Farms	78.84
State Forest Lands (1911 to 1921 inclusive)	
Northern Sweden	7.07
North Central Sweden	21.84
Central and South Sweden	27.15
Average for all State Forests	$11.77

* Statistics from Swedish Department of Agriculture.

The desire for a permanent supply of raw material is the great incentive that urges private owners in Scandinavia to go into forestry on a sustained yield basis. It is not a very progressive enterprise that lacks the ambition to grow and expand. Since the area of land is limited, and more land means more taxes anyhow, quite a few of the forest owning utilizers practice very intensive silviculture in order to increase their wood supply and consequent output without impairing the future prospects of the business. Such programs of better silviculture may be thought slow in attaining results, but experience is otherwise. Inventories and regulation calculations in a decade or so invariably show substantial gains from good technical direction of operations on a forest property.

One great advantage that makes for good forestry in Sweden by contrast to the slow and hesitant progress the science shows in America, lies in the proximity of Central Europe with its justly famous attractive and profitable woodlands. These have long been ideals toward which the Swedish owner strove. As long ago as 75 or 100 years, the desirability and possibilities pertaining to orderly and intensive forestry were appreciated by all better informed men of affairs. Trained German foresters in considerable numbers were employed from time to time, but their achievements were either quite mediocre or absolutely disappointing. True to their national characteristics, these men could not adapt themselves and their forestal knowledge to the conditions that confronted them in Scandinavian lands. The most serious errors forestry has ever made up there can be traced directly to the blundering attempts to follow in detail prescriptions worked out for forests where climatic, economic and topographic conditions were radically different. When, a little later, the Swedes themselves began to study elemental and basic principles underlying forestry, results were much better.

It may be surmised from the foregoing that private forestry antedated the activity of the government in the field. This is true with respect to a rather irregular and scattered series of attempts. The most forestry progress prior to 1870 was made by the iron industry corporations and owners. A few of the large landed estates also had their forests under systematic management. It might be justly said that quite opposite courses have been followed in Sweden and America in respect to the introduction of forestry practices. Here the nearly universal rule has been government forestry first and trailing along later we see the private land owners taking a real or interrogative interest in the possibilities of the science.

There are many excellent examples of intelligent and intensive management of private forests in northeastern Europe. Below is given a condensed description and two tables that set forth facts about one such private forestry venture that will serve as an example and show how carefully the details of correct business methods have been applied on these properties.

TABLE XIX.—Gross Production from 71,660 Acres of Forest, Stjärnfors, Sweden (cu. ft.)

Yr.	Quantity	Yr.	Qunatity
1907	1,907,000	1913	2,507,000
1908	2,543,000	1914	2,260,000
1909	2,385,000	1915	2,401,000
1910	3,638,000	1916	2,225,000
1911	3,567,000	1917	2,366,000
1912	2,649,000	1918	2,084,000

Average per yr. = 2,684,000 cu. ft.

The Ställdalen Company property at Stjärnfors, Sweden, embraces 98,840 acres. Of this, 72.5% are productive forest land, 15.3% is waste areas, 9.4% is grass land and steep slopes, and 2.8% is under cultivation or occupied by buildings. The 71,660 acres of forest are classed as 14.7% good, 68.1% medium and 17.2% poor.

As is the case with nearly all the large land-owning corporations in Sweden, this concern does not put much restriction on the management of the estates with respect to products. Results of a satisfactory financial kind are demanded and the maintenance of the physical features is presupposed. It is but natural that a corporation engaged in the working of iron should require its lands to produce those raw materials needed, but it is not uncommon to see them temporarily buying these in the open market and working their own wood up into some shape that brings a slightly greater net income than their expenditure for replacing such needed materials as might have been yielded. Business men in Sweden are, and must be, keen and careful in calculating marginal profits; otherwise they could not make head against competitors in the more favored lands to the south.

This property had a trained forester and assistant with eight rangers in 1918,—for which year succeeding data applies. There were then 314 cottages housing a slightly greater number of families. A total of about 900 milch-cows and 200 horses were maintained by the company and its lessees.

The growing stock averages 1,144 cu. ft., or nearly thirteen cords per acre. This rather low stocking is due more to the low age of the stands than to deficient density. Only 6% of the area supports stands above eighty years old. These stands contain 12% of the total growing stock on the property. The average annual cut per acre during the 1907-18 period has been 40.47 cu. ft., or about 3½% of the G. S. The M. A. I. percent over the whole forest is estimated at 4%, or 3,279,000 cu. ft. of wood. This compares very favorably with the average cut per year given at the conclusion of the above table and shows that the forest as a whole is being built up at the rate of about 6,600 cords per year. It is worthy of note that the booming business conditions of the War period did not tempt the management into violation of their cutting budget. The disposition of the gross income is quite illuminating, and demonstrates clearly that forestry can "stand on its legs." The expenses of utilization are one-third of the gross income. Another third goes into administration, protection and taxes; leaving one-third as interest on the property investment and profits.

Complete records are at hand showing the character of the products taken from this forest during the period covered by Table XIX. The average annual yield of various items is set forth in Table XX, and illustrates how important the low grades and small sizes are. This is to be expected, however, when a rotation of under ninety years prevails. Pine and spruce are about equally common on the areas, and growth is quite in keeping with that shown in Table XVII for Malingsbo.

TABLE XX.—DETAILED ANNUAL YIELD FROM THE STÄLLDALEN CO. FOREST (71,660 A.), STJÄRNFORS

Character of Product	Quantity per yr. (cu. ft.)	% of Total
Fuel and other Household Wood	353,160	11.6
Stumpwood for Distillation, Props. etc.	102,416	3.8
Charcoal Wood	879,368	32.8
Paper Wood	557,993	20.8
Cordwood for Other Uses	187,175	7.
Saw-timber and Ties	603,904	24.
Totals =	2,684,016	100%

Many of the iron-working corporations own forests that approach the normal-ideal in regard to age-class and stocking distribution. An example is cited in Table XXI from an inventory made in 1912.

TABLE XXI.—Age-class Conditions on Lindenäs Factory Forest, Nås Parish, Dalarna, Central Sweden

Age—Yrs.	1–20	21–40	41–60	61–80	81–100	101 & Over	Totals
Acres	8,648	8,600	10,304	12,602	8,896	7,278	56,328
% of All	15.3	15.3	18.2	22.3	15.7	13.2 =	100%

	Timber		Paper Wood (Loads)	Charcoal (Loads)	Totals
	6″-9″ at little end	9″ and over at little end			
On Total Area	2,411,398 logs	479,903 logs	411,300	457,000	64,640,000 cu. ft.
Per Acre	51.2 logs		7.3 loads	8.1 loads	1,146 cu. ft.
In % of Total G. S.	31.8%		15.7%	52.5%	100%

On the above property the rotation was nearly 120 years in actual practice. There is rarely, in Sweden, a very close adherence to a definite rotation. The general appearance of stands and what the increment-borer shows them to be doing is most frequently decisive in filling up the felling budget. This seems quite rational and worthy of imitation elsewhere, with the possible addition of such attention to the soil and stand conditions as may be required to get good regeneration.

COMPARISONS WITH AMERICAN CONDITIONS

It is but reasonable to inquire why forestry has made so much greater and more substantial progress in Sweden than in America during the past half century. Our business and political leaders admit the ultimate and rapidly approaching absolute necessity that American forests be put under good sustained yield management, yet only with the utmost difficulty can funds be obtained to merely protect our natural growth against fire. In fact, not 20% of our total area of forest is adequately guarded in this most fundamental respect.

Sometimes the time-worn and ragged scarecrow of European cheap labor is set up as the reason why good forestry flourishes in the Old World and is so slow to take root here. When the much greater efficiency of American workers, and our use of machinery and organization to save labor and enhance its effectiveness, are weighed in the balance, mere wage rates mean little or nothing. This is readily seen in America itself, where a vast difference prevails between the pay, food and accommodations colored laborers get in the southern pineries as compared to forest workers in the Pacific Northwest and Canada.

In 1925 woods labor in Central Sweden received $1.88 for a day of about ten hours. A man and horse cost from $2.70 to $4.00 per day. This is a much lower rate of pay than prevailed during the War. At that time, in the same locality, men were paid $2.46 per day; with a horse their average pay was $6.22. Oxholm gives carefully compiled figures [45–75] that illustrate the wages paid in 1918 and the variation in different sections of the country. It is probable that labor in Swedish forest industries surpasses in efficiency that in any other European lands with the possible exception of Finland, but it is much less productive of results than our own.

One of the most outstanding factors that favor forestry as a business in Sweden and most of Europe is the climate. Money always makes men conservative or even cowardly. As soon as the word *forest* is mentioned to the average American investor, he at once thinks of *fire* and the long period of risk. In northwestern Europe such a psychology does not afflict the forest owner or investor. In fact, he looks upon woodlands as a most stable form of property constantly tending to increase in value. From a forestry standpoint, a member of that profession quickly observes that Sweden possesses in her climate a great advantage over most of North America; *i. e.,* practical immunity from serious forest fires, if ordinary precautions are observed. The direct reason for this immunity is the luxuriant growth of grasses, moss, heath plants, etc., on the forest floor nearly everywhere; together with constant high relative humidity, which keeps this vegetation and the underlying soil perennially moist,—as compared with conditions in most U. S. forests. This high relative humidity has some economic disadvantages,—tourists always note that it compels the farmers to hang their hay " up on the fence " in order to dry it. In places the forests suffer, too, from rising of the ground water level, often over large areas; producing the effect known as " försumpning,"—a slow drowning out of the forest due to naturally poor drainage combined with extreme development of certain mosses and associated plants. On extensive areas, also, the trees become densely clad with lichens; even out among the foliage. These lichens are apparently always detrimental to the best growth of trees, and may directly or indirectly kill them, although usually only the shaded lower limbs die. Forest owners combat the effects of excessive moisture by expensive drainage projects, and by cutting carefully.

In view of the above facts, it is a surprise to note that the average annual precipitation in Sweden is less than twenty inches, and in some localities only seventeen inches. In extremely dry years it has fallen as low as twelve inches. The 1924 season was considered a very warm and dry one, yet the forest floor always seemed quite moist everywhere. Pennsylvania has an average annual rainfall of nearly forty-five inches and a range between thirty-five and fifty-five inches, yet forest fires rage almost yearly and tree growth is commonly limited by insufficient moisture. In fact, such a low precipitation as we find in Sweden would, in the U. S., scarcely support an open stand of western yellow pine, or similar drought-resistant species, and the region would be semi-arid.

The luxuriant forests and other vegetative growth in Sweden is not entirely due to the high relative humidity. Two other factors in a small degree at least favor vegetation. (1) The soil possesses a good store of soluble mineral fertility, if unfavorable acid conditions do not develop. In many places the soil is a fine glacial till or clay which is very retentive of moisture; but there are also vast areas of sand, coarse gravel and boulders, that leach and drain out just as rapidly, if not as completely as our similar sites. (2) The soil cover is usually much better than found in American forests, since litter decays slowly because of low soil temperatures; which antithetically, are in a measure due to rapid and constant evaporation from the mosses and other moist vegetation whenever the atmosphere is above dew-point. Intensive scientific study of forest floor conditions in America would probably yield facts which, in combination with complete protection, should give many of our areas better ability to retain moisture in spite of the continental climate we enjoy. Higher soil moisture would also mean greater wood increment.

The individual trees in Sweden make less increment than trees of the same genus do in America, as a rule; because of our longer growing season and higher temperatures. This is especially noticeable as regards seedlings in the forest nursery and height increment generally. Increment of wood per acre, however, tends to be as good or better than in American forests, due to the usual large number of stems per unit of area.

It has been said with justice that " no country ever started to practice forestry until compelled." The compulsion is sometimes of a general economic or other nature, but in most European countries it has been the fear of a fuel famine that turned men's thoughts toward rational forestry. In Sweden this factor is doubtless operative, but economic reasons weigh heavily in the minds of statesmen and industrial leaders. To any student of world trade, it is evident the forest is the resource that must meet the bills of international exchange, otherwise prosperity languishes, idleness stalks abroad in the land, progress in general ceases, and living standards fall. It will not be denied, however, that a nation's own wood needs are strong incentives toward a proper appreciation of the major forest benefits; especially in a cold and humid country where coal is practically absent and wood is the chief building material.

No Old World peoples, except the Finns, use wood in such quantities as we do in North America. Even in the country districts of Central and South Europe, houses of stone and brick with tile roofs are almost universal. In many regions wooden roofs are forbidden by law. It is north of the Gulf of Finland and the Baltic outlets that the wooden house begins to predominate. In these lands only the larger cities discriminate against wood for general building, altho wood-shingle roofing is frowned upon and very rarely seen. The frame house, painted red with white trimmings, or in other cheerful colors, is typical of most landscapes. It is an effective and comfortable structure for human habitation, and has been a tradition of the Norse peoples for centuries; to judge by tradition and appearances. Nearly every town and city of Sweden has been harried by fire from time to time in the past. The reason for the prevalent conflagrations lay in the wooden construction and the cold, disagreeable climate, which induced vigorous firing and overheating of flues or throwing showers of hot sparks.

It cannot be said that the Swedes today are very careful in habits and usages with respect to fire,—the invention and general use of safety matches to the contrary notwithstanding. It is almost impossible to find a modern fire-escape on any building in all Stockholm; altho the prevailing type of construction is only "semi-fireproof," and family customs, as well as national traditions, require each room to be stuffed to its limit with inflammable hangings, bric-a-brac and furniture.

TABLE XXII.—Annual Consumption of Wood [77–50 and 52]

Country	Per capita Consumption	Percent Saw-timber
Canada	285 cu. ft.	32.3
Denmark	24 cu. ft.	66.7
Finland	299 cu. ft.	60.6
France	26.3 cu. ft.	39.1
Germany	27 cu. ft.	66.6
Great Britain and Ireland	15.3 cu. ft.	96.4
Holland	15.8 cu. ft.	84.6
Italy	15.4 cu. ft.	34.7
Norway	118.2 cu. ft.	52.
*Sweden	129.3 cu. ft.	51.1
Switzerland	28. cu. ft.	49.9
United States	228 cu. ft.	56.2

*The per capita consumption given in the table is probably somewhat high. On the basis of some quite recent studies (22), it would be only about 113 cu. ft. per capita.

Fuel is the great need of these northern lands. Peat is not very popular as a fuel in Sweden. It is abundant but not used by the Swedes to the extent the Irish, Danes and Norwegians do. It is more frequently used to heat cow-barns in Norrland than for fuel in human habitations. The people much prefer the cheerful crackle and sparkle of wood to the slow smoldering glow of peat. The fuel needs of Sweden are in excess of 430,000,000 cu. ft. annually, or 72 cu. ft. per capita. This item varies much from south to north. In the province of Vesternorrland, where the climate is quite severe, a thorogoing investigation found that firewood used per family per year was 1,830 cu. ft., or over 300 cu. ft. per capita when six is considered the average number per household. At the time this study was made (1919), the above fuel requisite for a family had a market value of $56.06. The total consumption of wood per family in the province averaged 2,871 cu. ft., with a value of $184.10. This is a per capita use of nearly 480 cu. ft. per year, and is in part explained by the fact that the section of Sweden under consideration may be classed largely as the frontier of culture and cultivation, where considerable new building is in progress.

The almost universal type of wood fence is a great demander of low grade material. It is not very durable, either, and must be replaced every few years. The racks for drying hay require an equal or even greater quantity of small poles in some agricultural sections.

Swedish railroads require annually the replacement of 1,000,000 ties for the state-owned lines, while the private mileage requires 1,500,000 in round numbers. The type of steel crossties, so commonly used in Germany, has not yet been adopted in Sweden.

The rapidly increasing population, and high per capita wood consumption in the U. S. A., even compared to the Baltic countries, is another very real reason for deprecating the slow adoption of forestry by our land-owners.

The forest lands and stands in Scandinavia yield few by-products. The ground litter is at times collected for use in bedding down animals, but it is not so much sought after there as in Germany. The peat mosses and associated plants yield so much more abundantly and are more easily collected. Their absorbent capacity is also very much above woods litter or any other material.

The soil and climate is highly favorable to growth of grasses and associated herbs. These plants are utilized for pasture, as heretofore described; but under most conditions, it is questionable policy. The woods grown grasses are quite low in nutritive value and grazing injures the present as well as future forest in more ways than one. Shallow rooted trees are probably more liable to damage than are species that root more deeply. Trees with superficial root-systems are more liable than deep-rooters to the destructive attack of heart-rotting fungi. These, in many instances, gain entrance thru the roots, and it is logical to think that injury to these organs predispose them to entry of the fungous mycelia. A few years ago the European trembling aspen was investigated in Sweden with the object of determining why it seemed to grow less vigorously and thrifty there than formerly. This study was of practical interest to the safety match manufacturers, since they now find it nearly impossible to obtain the good grade of aspen wood needed in their industry without going to Finland or Russia. The investigators finally concluded that grazing in the Swedish aspen forests was the chief cause of the deterioration of the species. During times when the soil is moist, the sharp hoofs of grazing animals scar and abrade the tender bark on the surface roots of the tree, and these injuries are the source of the fungous development, which unfits the wood for match stock. The forests of North Russia and Finland are practically ungrazed, hence the aspen is free of discoloration and decay.

Tanbark from the oak is sometimes harvested in South Sweden, but is not of much importance. The oaks are now quite limited in distribution and the tannic acid content of the bark is not quite so high as further southward. Some tanning is also done in a small way with birch bark.

The leaves of Beech in the province of Skåne are harvested in some places during late May and early June for dyeing in connection with use by florists and in general decorative work. Small branches or boughs are cut as soon as possible after leaves attain full development. They are then treated with certain chemical compounds which harden and preserve the foliage and twigs in its best spring form and beauty, while at the same time imparting thereto a blood-red or red-brown color.

The long winter period in the north of Europe is quite dreary and tiresome. The Swedes, more than any other people, have learnt to use every resource their land affords to cheer and brighten the cold and dark winter. The forest greenery is much called upon in this connection; not only for holiday season decorations, but at all times. The boughs of pine and spruce are most commonly used, but birch twigs are also collected and used after they have been kept in a warm, moist place long enough to force vernation of the tender leaves that slumber in their gray brown buds. The green twigs of *Juniperus communis*, with their wealth of berries, are much sought after. *Lycopodium* sp. and the berry clusters of the European mountain ash are popular, along with a host of other plants in their season of bloom or fruiting. The collection of all this material and its marketing occupy many a person who would otherwise be idle. The use of

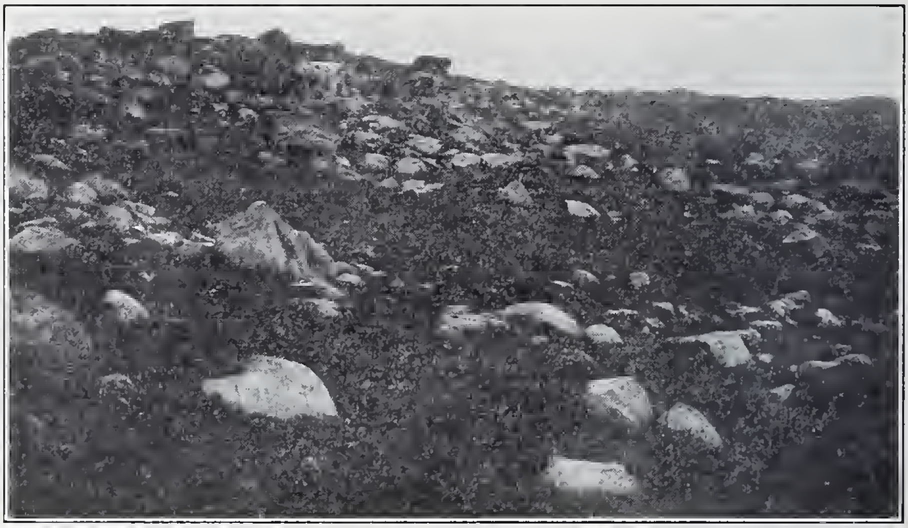

FIG. 3.—HEATH AREAS IN SOUTHWEST SWEDEN DUE TO GRAZING.

In the old Viking days these hills supported a good forest of oak and beech. The trees were cut away and lands have been used for centuries as a common pasture ground. Fire has been used to "improve" the grass from time to time, but now only the coarsest heath plants remain and erosion has almost destroyed the productive possibilities of the site.

these cheerful decorations from the very heart of nature is pleasing and commendable, but it has the same disadvantage in accentuated form which mars the Christmas tree custom. There is a too general disregard of property rights by the collectors as a group, and even in some cases where the evergreen tree material is collected by or at the direction of land-owners themselves, many vigorous and promising trees are robbed of their thrifty leaders.

As a class, Swedish foresters probably look very favorably on the collection and use of the Scotch heather (*calluna vulgaris*) in the interest of beautifying homes and business places. No plant is so thoroughly disliked by the practicing forester. Its presence on land not only betokens its acid and sterile condition, but by reason of its dense clumpy growth and fine matted roots, regeneration of the forest is much hindered. As an ornamental, it is most attractive and takes on a sort of "immortelle" appearance when it ultimately dries up.

Numerous species of edible fungi are collected in the forest.

Berries of the genera *Fragaria* and *Rubus* are collected in considerable quantities. The "lingon" or European cranberry (*Vaccinium vitis-idæa*) is the most important Swedish forest fruit. It is collected in vast quantities in some localities when a favorable crop year occurs. It is largely marketed in Central Europe, and many carloads cross on the ferry to Germany when it is in season. The fruit is red in color and only as large as a small blue-berry. The American cranberry (V. *oxycoccus*) also occurs in Sweden, but is rarely or ever used, due to its marked acidity. The fruit of *V. vitis-idæa* is not very noticeably acid, but is rather astringent.

The greatest of all U. S. A. forest by-products is resin and turpentine. These have, in times of trade suspension, been collected from the pine in Sweden, but the flow of gum is not at all comparable to that shown by our southern pines and the maritime pine of France. Tar-burning is somewhat more remunerative, and the industry is really on a competitive basis with the world in localities where there remain stands of old virgin growth whose stumps and lower boles are heavy and rich. In lower Norrland a practice arose in this industry which is deprecated by foresters. The tar-burners, a long time before trees are to be cut, remove the bark in narrow perpendicular strips from the ground up as high as they can conveniently reach, on the tree boles. This stimulates the deposition of resin and makes good, rich, raw material for their industry in course of some decades. It, however, somewhat slows down growth, increases injury in case of fire, and unfits the butt-log for high grade lumber. Just how effective the practice is in raising the yield of tar cannot be stated.

The discussions and comparisons here set forth ought to definitely and irrefutably prove the magnitude of the opportunity which lies before the forest land owners in the U. S. A. and Canada. Considering Sweden as an example of all Northwest Europe, there is scarcely an angle from which we do not have an obvious vantage ground in the field of forestry. We have the greatest home-market in the world for forest products. We have woodlands that yield numerous indirect values and important by-products,—in sharp contrast to the general case in Sweden, Finland and Norway. Why, then, has forestry taken sturdy strides in these lands while it totters and blunders along in America? It is not alone sufficient to say that absolute economic pressure has forced these lands into forestry, because they have been less richly endowed by nature along other lines. It is ventured for argument, that the boasted enterprise of American business is more a fiction or fallacy than a reality. Money in America, more so than in most lands today, is in the hands of the ultra-conservative. These are the persons to whom we must look for real private forestry. In spite of the relatively satisfactory status of our average citizen, we require all we can earn to maintain our high living standards. The pioneer gambling spirit is deader in the U. S. A. than in any land on earth. We may be fortunate that this is true. It may be due to fewer of our people, than ever before, or than anywhere on earth, being in the condition of having " Nothing to lose and everything to gain." It may also be due to a realization that we live in a day of big organizations. Small undertakings do not seem worth while or safe in competition with giants. Is it not a proof of the decadence of enterprise when business spends so much time and money pleading for guaranteed dividends? Witness the tariff and railroad questions. Why does our merchant marine dwindle from the high seas and Muscle Shoals go begging for a buyer? The fear of government regulation and restrictions is often given as a reason for the timidity of the dollar here at home. It is an excuse, not a reason. Many who control or own capital would rather place it in foreign lands at usurious interest rates and trust to being able to guarantee them by American lives and patriotism, than venture into new home fields where regulation or competition will never permit much above a fair income.

Since wealth is not much bolder in Sweden than in other lands, why does private wealth find the forest a satisfactory investment? The frequent union of forest ownership and big utilization plants is one reason. Yet we have this in America without much or any rational forestry. There are three reasons for the promising progress of Swedish private forestry:—(1) The government on its extensive areas is practising the best possible methods and making it pay. (2) Careful experimental work lies back of most methods in use, and there is no dearth of funds to support forest research. (3) Laws compel landowners to take proper management measures or forfeit both land and crop under certain conditions.

It is now interesting to hear many big forest owners and utilizers support the compulsory laws they once denounced and loudly deprecate the poor care farmers often give their small but potentially very productive woodlots. A good government example, coupled with research on the problems confronting forestry, and then a club held over the head of big land owners, is the explanation accounting for much of the best private forest management in Sweden.

CHAPTER IV

FOREST INFLUENCES AND INDIRECT BENEFITS

In a land where forest covers 60% of the total area, it naturally impinges upon the life of the people at every angle. It works directly and indirectly on the economic and domestic thought. It weaves itself into the art, folk-lore and literature. It plays a part in customs, religion and the course of national development. In fact, as the giant Atlas supported the ancient world, so today the world of Swedish life rests on the wide shoulders of the Forest.

The character and growth of trees are everywhere determined by climate and soil. Of these two great groups of factors, climate is nearly always controlling as to whether a forest can maintain itself or not. The nature of the forest may often, however, be dependent upon soil factors. But just so certainly as the foregoing is true, so also both climate and soil are more or less modified and, even in case of the latter, at times entirely due to the forest. From the preceding chapter, it has been seen that the climate of Sweden possesses certain peculiarities. An attempt will now be made to correlate the forest with the weather and edaphic conditions prevalent in Scandinavia.

CLIMATE AND FORESTS

It is evident to the thoughtful student of meteorology and associated subjects, that the two great types of climate, continental and oceanic, respond quite differently in respect to the modifying power of vegetation or the presence of inland waters. The effect of large areas of green forest is very like that exerted by open bodies of water. In fact, some physicists consider the forest more efficient, with its large total surface of transpiring leaves and green twigs, than an equal area of water, as to increasing the humidity of dry air currents that pass. When the atmosphere is already charged nearly to the dew-point, the forest does not very perceptibly add to its moisture; in fact, may occasionally subtract from it. The moisture-laden air current is not extreme in its temperature, but tends to equability.

Since all Northwest Europe is blessed with humid breezes from the Atlantic Ocean and the Baltic complex, the forest, during most of the year, exerts only a minimal influence on temperature of the air. It does, on the other hand, through control of soil heat, practically determine floral and soil faunal conditions over great areas.

The physical resistance offered by tree growth to passage of air currents is very important in lands where the winds may be violent in their velocity and very disagreeable to man and animal life because of their humidity, which renders cold so much more effective in decreasing body-temperatures. The old axiom, " Winter's fog will freeze a dog," bears testimony to the general appreciation of humidity as a factor adding to the discomforts of winter in the higher latitudes. When the humid winter wind blows an almost constant gale, as is the case in many coast-land regions, the discomforts are more than doubled. The Danes, and in some localities the Norwegians, have planted extensively to secure shelter against the cold ocean winds. This has not been necessary in Sweden, except in possible rare instances; since the land as a whole lies in the lee of the Kiolen Mountain ranges, and supports nearly everywhere, except at the extreme south, abundant forest growth, especially on the higher lying moraine ridges; thus giving human habitations good natural shelter. It is quite noticeable, too, that most builders and home-keepers have made an effort to take advantage of forest growth, as well as topography, in locating and maintaining residences and home grounds.

Many of the factors of soil and climate are closely related; hence it is impossible to discuss one set without constantly referring to the other. One of the striking features of Swedish climate is the low total annual precipitation in conjunction with high relative humidity, frequence of cloudy weather and the total time when precipitation is actually in progress. It often made the author wonder whether Swedish statistics on rainfall and snow gave fair, deficient, or excessive values for the moisture that actually reaches and enters the forest soil. As evidence to show the increased water reaching the soil because of forest growth, may be mentioned a common and beautiful phenomenon of Swedish autumns and winter,—rime frost. When this crystal frost clothes all vegetation, as is often the case, it cannot be doubted that a considerable quantity of water is being abstracted from the atmosphere by every tree, especially of evergreen species, which rain-gauges generally fail to record. Of course, when these instruments are located under a forest canopy, they may catch a fraction of the water when the frost melts, but some evaporates and much follows the tree branches and bole directly into the soil; being thus more effective than that which drops to the earth; since this latter moisture must run the gauntlet of the heavy humus cover, as well as the more or less dense ground cover, before it becomes available in the mineral soil.

In spring and at times in autumn and winter, when it is too warm for frost to form, one often sees every tree twig and needle dripping moisture while the air is filled with a light fog that does not moisten other objects noticeable. This condensation is usually very noticeable along city streets by both night and day. Under trees, the pavement will be kept wet for successive days, while the surrounding surfaces are practically dry.

It is probable, however, that these sources of added soil moisture for areas under forest, as compared to cleared land, are more than counter-balanced by the moisture which tree crowns intercept; so far as Swedish climatic conditions are concerned. It is characteristic there, that rain falls quite slowly or in light showers. A hard, drenching rain is rather unusual. Thunder showers are rare. Due to the way in which much of the precipitation occurs, a relatively very great part is retained by the foliage and branches in stands of pine and spruce. Probably much more would be retained and ultimately evaporated back into the air if the climate were less humid. As it is, the forest canopy tends to remain wet and slowly drip water down to the ground much longer than is the case in American forests generally. The amount of water which follows the trunks of trees down to the ground is dependent (1) on the angle which the branches make with the trunk and (2) on whether the bark be smooth or scaly. Studies under European beech stands show that as much as 15.4% of the total annual precipitation may follow the branches and trunks down to earth. For pine and spruce, with a habit of branching hori-

TABLE XXIII.—INFLUENCE OF FOREST CANOPIES ON EFFECTIVE PRECIPITATION

(Data from France and Central Europe)

Species	Number of Studies	Ages of Stands Studied	Amount of Precipitation under Stands in % of that in the Open*		
			Average	Lowest	Highest
Silver Fir	1	20 yrs.	20%		
Spruce	11	20–60 yrs.	69%	47%	88%
Beech	17	20–100 yrs.	73%	68%	92%
Pine	5	20–80 yrs.	74%	64%	82%
Larch	1	50 yrs.	85%		
		(Sweden)			
Scotch Pine	3	80 yrs. to very old	87%	72%	102%†
Norway Spruce	3	60–70 yrs.	79%	72%	90%

*This table takes no account of that water reaching the ground by following the bole but only what was caught in rain-gauges.

†The precipitation value of 102% was read under a very old pine stand. It is likely accounted for by factors heretofore discussed. The values in Table XXIV also emphasize the importance of condensation on twigs and boughs.

TABLE XXIV.—PRECIPITATION UNDER FOREST

Species, Age, and Density of Stand	Amount of Precipitation beneath Stands, in % of the total in the Open		
	Average for year	Dec. to. Mar. incl.	April to Sept. incl.
Dense 50 yr. old Beech	75%	105%	70%
Thin 50 yr. old Beech	77%	104%	73%
Thin 40 yr. old Norway Spruce	107%	111%	106%

zontally, the water running down the boles average only 0.7% and 2.3% of the total amount for the open [3–102].

The rate or rapidity of precipitation is an important factor in determining what percentage of total water reaches the ground. From a spruce forest near Stockholm the Swedish Forest Service secured the data in Table XXV. It is not of much direct value, but does show how the proportion of the total rainfall reaching the forest floor greatly increases with the heavier showers. It is also a potent fact that our rain and other forms of precipitation in America is much more likely to occur in heavy showers instead of the light ones that are characteristic of North Europe. Few of our forests in the U. S. A. approach, in density of crown canopy, the average Norway spruce stand, so it follows that American forests generally retain in their canopies a much lower percent of the total precipitation than do Swedish coniferous stands.

TABLE XXV.—PERCENTAGE OF PRECIPITATION IN THE OPEN REACHING THE FOREST FLOOR FOR SHOWERS OF VARYING INTENSITY

Amount of Precipitation in 24 hrs. (inches)	Under Dense Forest (%)	Under Medium Dense Forest (%)
0.04 to .12	1–16	35–58
.13 to .20	7–43	61–87
.21 to .40	22–46	81–93
.41 and over	50–75	98–100

The distribution of precipitation in Sweden, or for that matter all Western Europe, with respect to time of year, is quite different than that found in the eastern and central portions of North America. In general, spring and late winter are our seasons of heaviest rain or snow. These are the periods of least precipitation in Sweden, while late summer and autumn have the greatest.

TABLE XXVI.—AVERAGE SEASONAL PRECIPITATION IN EUROPE AND AMERICA (INCHES)

Place	Dec.-Feb.	Mar.-May	June-Aug.	Sept.-Nov.	Total for Year
Lund, Sweden	4.79	4.45	7.74	6.66	23.64
Stockholm, Sweden	3.19	3.59	6.59	5.26	18.63
Haparanda, Sweden	3.86	3.09	5.24	6.23	18.42
Rothamsted, Eng.	6.45	5.87	7.51	8.19	28.02
Portland, Me.	12.44	11.06	10.82	10.18	44.50
Average over state of Ill.	6.81	10.49	10.41	8.02	35.73
Average for Tenn.	15.95	14.69	12.91	10.35	53.90

[33–15 and 20–377]. The values in Table XXVI are typical averages. They serve to illustrate one respect in which most of North America has an advantage over Central and West Europe in regard to both agriculture and forestry. It is much to be preferred that rain occurs in the growing season rather than from late August to November, as is the case of the heaviest European rainfall.

Late spring and summer are the period when plants possess greatest photosynthetic power. The presence of abundant soil moisture at that time enables carbohydrate elaboration to proceed unabated during the maximum insolation period of the year, and when nearly all forest trees, as well as most farm crop plants, bear their greatest burden of effective foliage. This fact, added to the heavier general precipitation and lower latitude of the North American temperate forests, should enable us to practice rational forestry on much shorter rotations, where production of a given dimension is the object, than is the case in Central or North Europe, where the growing season is so much shorter and the full power of the sun is often masked behind clouds and fog.

It is quite generally accepted now, in those regions of Europe where the total rainfall is low, that forests reduce the amount of run-off as compared to other uses of the soil. This matter was long debated, and good authorities often took opposite stands [58–29]. Hesselman cites two quite conclusive instances that illustrate the large amount of water required to supply moisture for transpiration of a forest stand.

From the steppe region of South Russia, or rather from the transitional belt where thin woods and grass-land struggle for supremacy, comes the following experience. In this locality the water question was of great direct import to the population and for successful cultivation of crops. It was necessary to economize to the extreme and make the fullest use of all moisture that reached the soil. Out of respect to the opinion that the forest was a great conserver of water, plantations were established in many places to attain this result; so that in certain localities a considerable fraction of the total area was put under forest growth. The result, however, did not at all meet expectations. Dams that had previously been constructed to retain water and had always been quite effective, even holding some water in late autumn, began to fail earlier and earlier with each passing year, just in proportion as the forests on their catchment areas developed; until finally the water already dwindled away in May. The actual result of afforestation, therefore, was the exact opposite to that expected. A definite decrease in the amount of water delivered to the dams occurred as the forests grew. Hydrologic investigations followed, and showed plainly that the ground water level beneath the steppe-forests always stood lower than it did under adjacent treeless areas. A profile line plotted from borings going from the treeless steppe into the forest, showed a sharp drop in the ground water level in every instance. Often a difference of sixteen feet would be found in a distance of 300 feet, although the surface of the soil was quite even and its character homogeneous. The reason lay in the heavy transpiration of the trees, which required more water than was available beneath them or could run in from the surrounding soil.

It must be kept in mind that the above effect of the forest is not to be expected upon steep sloping sites, or where the soil under non-forest conditions becomes quite compact. Under such circumstances, the surface run-off is considerable where forest débris and humus are not present to retain the water that falls. It is obvious that the restraining influence of the litter as to run-off may frequently increase the amount of water that goes into the soil, by more than the forest transpiration exceeds ordinary evaporation and other " fly-off " losses from open areas.

The influence of a forest stand on the level of the ground-water is, therefore, dependent upon two oppositely working factors: (1) the restraint of run-off by litter, and (2) the increased loss of water by transpiration and evaporation from the aerial parts of the trees. The loss of water from this last is high, in keeping with two factors: (1) high winds and (2) where precipitation usually falls in short and light showers instead of heavy downpours. Under the last condition relatively a very small fraction of the total precipitation is intercepted and held in the tree crowns. In Sweden the light and frequent rains have a marked tendency to only wet the vegetation at certain seasons. This means that forests are soil drainage agents instead of water conservers on many areas. It is accepted as true in the usual forest practice with areas where the water table is rising and there is danger of the site becoming drowned. Such forest lands are never clear cut unless it is intended that a complete system of drainage ditches is to be dug. The more luxuriant and heavier the crown canopy can be kept on such areas, the more moisture it will require for transpiration and the better the soil will be dried out, especially at the close of the growing season.

It has been found that not all trees are equally effective in transpiring water. Von Hohnel, as long ago as 1875, made transpiration studies covering several European trees. His research was based on weight determinations for relatively small specimens. The results, therefore, possess merely relative value and cannot be used directly to calculate the transpiration of forest stands. One of the studies concerned European larch and Norway spruce. It was under way from the first of April until the close of October, or a full vegetation period. The respective amounts of water transpired by these trees per 100 grams of air-dry needles during the period were:

European Larch	125,600 grams
Norway Spruce	13,300 "

This shows that the larch in early life and during the growing months uses nearly ten times as much water as spruce on a dry weight needle basis. It serves to explain a most interesting experiment which the Swedish Forest Research station has conducted in Vermland, South Sweden. There, on a gently sloping plain, where drainage is poor, a larch plantation was established just prior to 1860. A certain amount of drainage work was done about 1865, but only traces of this are now visible. The surrounding area has grown up to a stand of Norway Spruce, and even intermixt or beneath the larch there are many spruce trees present. The surrounding pure spruce stand, however, is suffering from excessive moisture. At many times in the year, when one walks thru the spruce forest, water runs into his shoes, but just as soon as the edge of the larch growth is reached, one can walk dry-shod. The transition between the wet, swampy soil and the dry ground is quite sudden, and not to be explained by any other factor. It everywhere coincides exactly with the bounds of the larch stand. When the area is studied closely, everything indicates that the larch has brought about a radical change in the condition of the soil since it was planted. It may be thought that some difference originally existed which accounted for the planting of the larch on that particular part of the site which it occupies; as it is not at all easy to get larch established on sour wet land. This matter is explained in the "Annuals of the Vermland Mountaineer Association" for 1877, wherein the forester administering this area, recites how this sour, swampy area had been reforested by his predecessor by ball-planting of European larch, but that the trees failed to make noticeable progress until after certain drainage work was done, than they developed vigorously. This drainage seems, however, to have been almost wholly ineffective, or at least it had only a very temporary influence on moisture conditions, since the spruce shows by stem analysis that swamp invasion has been practically continuous for near a century. Careful studies show plainly that the rapid growth of the larch, with its other effects, have been the real cause of every difference between the site it occupies and those about it. These differences are not limited to the soil and its cover of vegetation, but are notable with respect to wood production.

Under the larch stand, its needles and branch offal make the chief soil cover with scattered living vegetation, including such indicators of good soil as *Oxalis acetosella* and *Maianthemum bifolium*. Under the spruce, needles are not an important fraction of the soil cover. Living plants, and especially such mosses as *Polytrichum commune* and *Sphagnum* sp., are much more common than beneath the larch.

Permanent sample plots are established in both spruce and larch stands. At the age of sixty years, the growth on the two areas compared as given in Table XXVII.

It is especially to be noted in these two stands that the understory spruce in the first are larger in both height and D. B. H. than the average trees in the pure spruce stand. This is very surprising, since the stand of larch has a sufficient sectional area at breast height to prove it possesses practically a normal crown canopy, and by its vigorous growth would be expected to strongly suppress any trees underneath. This reaction of the spruce is due in a large measure to the better soil moisture condition which the presence of the larch has brought about. But it also probably illustrates the power of the larch as a soil improver. This favorable effect of the genus as a whole has been frequently noted, and is worth the serious attention of silviculturists interested in raising the rate of production

TABLE XXVII.—Growth of Larch and Spruce Stands Per Acre at Sixty Years Old on Swampy Soil, Lesjofors, Sweden

Species	Number of Stems per Acre	Sectional Area at D.B.H. (sq. ft.)	Average D.B.H. (in.)	Average Ht. (ft.)	Volume (cu. ft.)	Increment	
						Mean Annual (cu. ft.)	Current Annual (cu. ft.)
European Larch Stand							
Larch	483	146.5	7.60	69.8	5.142	85.7	141.5
Spruce	302	29.1	4.28	40.6	607	10.1	27.1
Total	785	175.6			5.749	95.8	168.6
Norway Spruce Stand							
Spruce	912	58.6	3.5	28.8	937	15.6	41.6
Advantages of Larch over Spruce on the Site							
Absolute	127	117.0			4.812	80.2	127.0
Percentage	14%	199%			514%	514%	305%

upon the cooler forest soils of the world. In Scotland it was proven [71–7/1918–177] that European oak, under a practically full planting of Japanese larch, made better growth than oak in pure plantations on adjacent similar sites; while the larch yielded a handsome net profit when sold for pit-posts at the end of a short rotation.

In order to determine the possible effect of the larch upon the ground-water level on the Swedish area above described, four wells were dug on the same elevation contour running across the site. These wells were ten feet deep. Two of them were within the larch stand about sixty feet from its margin; while two were located about the same distance out in the spruce stands on either side. Two additional wells were dug closer together in the different stands, but not on the same contour. If the water level were determined by topography, the wells at the same elevation at least, ought to show about the same depth of water; especially since study of the soil at time of digging, showed it to be a quite homogeneous stony moraine deposit which was very compact in every case. A forest hard-pan was also present, but it was not so continuous or dense as to prevent the penetration of tree roots. The soil was the usual type found in Swedish forests, with a leached out layer, six or seven inches thick, just below the upper humus. Beneath this pale leached stratum, the soil was rusty to dark brown and gradually changed with increasing depth to the prevalent blue-gray morainal clay and gravel.

Altho soil conditions are identical, the root distribution of the two species was found to be quite different. Almost all the spruce roots are limited to the thin humus soil, while many of the larger and stronger larch roots penetrate quite deeply. Almost none of the spruce roots pass through the dense hard-pan rusty soil stratum, but many of the roots of larch do this. At a depth of two feet there is a rich network of larch roots, the average being one-eighth inch in diameter. Some few reached a depth of nearly four feet. When the hard-pan layers beneath the two stands are compared, it is apparent that these numerous penetrating roots have loosened the dense subsoil considerably in contrast to what is found under the pure spruce growth.

Measurements of the water in the above described wells, over a period of four years, gave striking facts concerning the fluctuation of ~~on~~ the ground-water. In winter and on occasions of very heavy rainfall in summer, the water level tended to approach, or would actually reach, the soil surface, but was always slightly lower under the larch than under the spruce. However, this difference was only a matter of a few inches at times of heavy precipitation and when the larch ~~was~~ were bare of leaves. But in June, when transpiration was most active and precipitation normal, the water level beneath the larch was more than three feet lower than under the adjacent spruce.

The foregoing may be an extreme example of the ability of the forest to lower the ground-water level by transpiration, but it must be remembered that tree roots are ever active in extracting water from the earth and throwing it back into the atmosphere, from which it is again condensed as rain, fog, or snow, when the air currents are later chilled by the upward motion characteristic of general low pressure areas, thunder storms and passage over mountain massifs. Such general effects of forests are everywhere active. Even the spruce stand in the preceding comparison, transpired an important quantity of water, as is realized when we remember that this species carries its foliage thruout the year and this is much heavier and denser per tree of given size than is the case with the needles of larch.

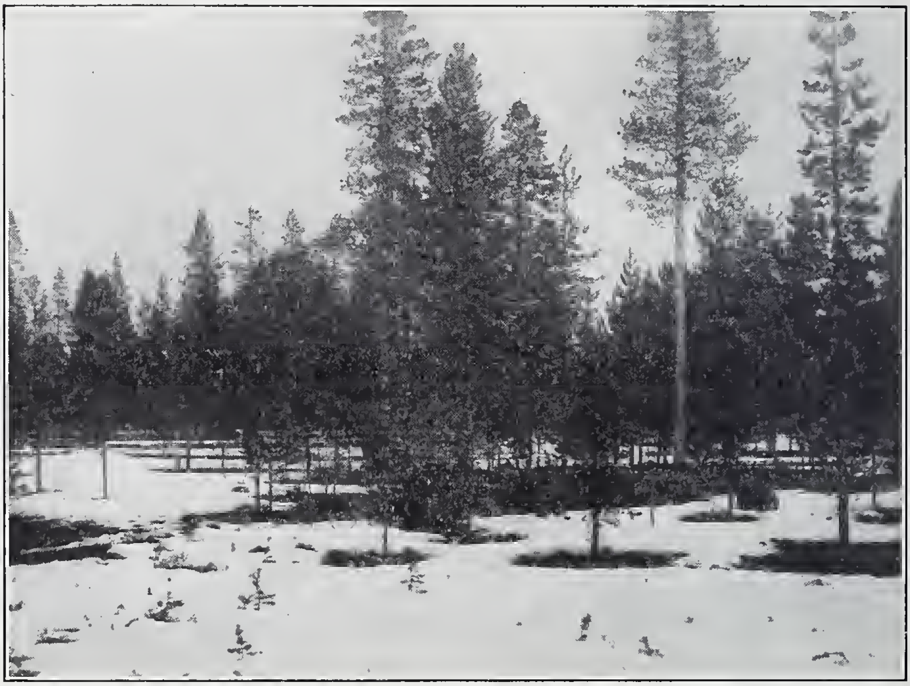

Fig. 4.—Young Growth on Pine Heath Area in North Sweden.

Unlike what is found in more temperate climes, the young trees grow best under the sheltering crowns of old ones. This is probably due to the fact that less snow reaches the earth there than between the crowns of older trees. Snow melts and soil warms up more quickly in spring, which is very important to trees near the cold limit of their occurrence. Scotch pine is a shallow flat-rooter here because the lower soil strata are always too cold to encourage root penetration.

In Sweden, it is usually assumed that cutting away forest growth from areas liable to swamp invasion hastens this process. Hesselman rather doubts this [58–50] where the original forest is putting on very little increment, as he assumes practically that transpiration is proportionate to increment. If old hyper-mature stands are replaced with thrifty vigorously growing young ones, it should therefore even result in a lowering of the ground-water level. The great danger in cutting seems to lie in the development of low, dense mats of ground vegetation, especially mosses and heath species (*Ericaceæ*), which choke up water courses; both as to the surface run-off and the pore space in the subsoil; while at the same time transpiring much less moisture than even a poor forest does.

The influence of forests is not so likely to be noticeable in a region where the relative humidity is generally quite high as where the air is dry. Swedish forests might transpire water in great volumes, but since the atmosphere in that practically oceanic climate is so often nearly saturated, the effect would be scarcely discernible, so far as modification of other climatic factors is concerned. It is always to be remembered, too, that transpiration is, within certain limits, greater or less in proportion to the saturation deficit of the atmosphere. The limit in this connection is the ability of trees to limit their water losses quite closely by adjustment of the leaf stomata when the temperature rises too high or the pull of evaporation becomes too great.

[65–185 to 196.] Where a continental climate prevails over vast regions, as is true in the U. S. A., forest stands must exert an effect relatively far greater than in regions of numerous glacial lakes or where humidity is high from the prevalence of ocean winds. This effect may often be quite local, but if the forests be sufficiently extensive, the aggregate influence ought to be considerable and somewhat comparable to that of a body of water, if not sometimes greater area for area; since the leaf surface of a tree stand is enormous and moisture, to a certain extent, is always being given off to the air when it is above dew-point. Guttation, in a meager way, is probably more common with forest trees than has yet been proven.

TABLE XXVIII.—Relative Humidity in Sweden and U. S. A. (by Percentage Averages for Months at 8 p. m.)

Place	Jan.	May	July	Aug.	Dec.	Total Year
Östersund, North-central Sweden	82	72	79	81	86	79
Uppsala, Central Sweden	90	73	74	72	92	83
Växjio, South Sweden	87	76	74	83	90	84
Albany, N. Y.	79	65	69	67	80	73
Columbus, Ohio	77	61	59	61	76	66
Omaha, Neb.	71	55	57	59	70	61
Seattle, Wash.	81	59	51	54	82	67
El Paso, Tex.	34	13	29	32	34	26
Denver, Colo.	49	38	36	33	48	39

The differences in relative humidity between the two countries would be still greater if some time about noon to 3 p. m. were taken for comparison. It is not easy to get good data, however, in this respect, but such as is available demonstrates that most of the U. S. A. is certainly in the "Intemperate Zone" as regards wide diurnal and periodic fluctuations in relative humidity [3–66 and 37–209].

HYDRO-ELECTRIC DEVELOPMENT

The forests are generally considered as vast reservoirs retaining water that would otherwise quickly run back to the sea. This conception of forests is a true one universally, but it will be found that over most of the U. S. A. forest growth has more importance in this connection than is the case in Sweden. It is altogether probable, from the foregoing, that forests in Scandinavia absolutely decrease the total quantity of water that would be carried by surface streams, and hence be available at one time or other for hydro-electric power. This is just as probably the reverse of actual facts in America with our continental climate.

Woodlands do always retard and decrease the flood peak stages in stream flow, and we cannot doubt but their effect in the U. S. A. is by and large far greater than in northern lands with a relatively equable climate and vast glacial bog and lake areas. The heavy evergreen forests doubtless slow down and retard the spring melting of snow and ice, but in Sweden this is only one of several factors that tend to equalize stream flow. With us in America, it is not only the greatest factor in controlling streams in the long run, but over vast regions the only practicable one. This should become, with passing years, an increasingly strong reason for requiring correct forest practices on all essential forest land in many localities.

Swedish water-power development is very well planned and thoro in all its details [27]. Most of the power is generated by the state, and private enterprise in the field must submit to close restriction. The organization and details of the industry are worthy of careful study and frequent imitation by economists, conservationists, and electrical engineers of most other lands.

The State Water Power Administration is entirely separate from the forestry and other conservation work of the Swedish government. It is concerned primarily with the hydro-electric development and canals. Since its establishment by parliament (Riksdag), in 1908, enormous progress has been made in the use of electricity by the Swedish people. In no land on earth, unless it may be Norway, has electric current come to be so important in the everyday life of the people. The humblest homesteads in many almost inaccessible localities are attached by wire to the main power nets.

Coöperative Distribution Societies are organized among farmers and other small users. They reduce greatly the amount of office and administrative detail the government would otherwise have to contend with. They also find their own capital by one or another approved plan, and may supply at government-fixt rates both current and equipment to non-members as well as member-consumers.

The forests of Sweden, however, deserve some credit for the power development possibilities of the country, even if they play an inferior rôle to what they would in the eastern U. S. A., for example. Already the country's engineers look forward to the time when all economic water, power in South Sweden will be fully utilized, and

[27–160] even with a giant-power system of interlocking high-tension trunk lines, dry seasons will limit the resources available. The forests, with their tendency to accumulate raw-humus on the soil, will both hold back heavy stores of the winter water to turn the generators at such a time, and aid in shortening the length of such seasons. Low water periods usually fall in late spring or early summer, and it is at just those times that the forests are still relatively moist and transpiring the water which gives rise to refreshing summer showers, that are often life-savers to agricultural crops and important sustainers of stream flow, even in a land of lakes and marsh areas.

The larger private hydro-electric plants are usually owned by corporations engaged in forest utilization and iron manufacturing in one form or other. One of the best examples in the field is the Stora Kopparberg Bergslags A.B. with very extensive forest holdings in Central Sweden. They own or control power sites with a practical potentiality of 200,000 horsepower, of which 170,000 has been harnessed to date.

The government built (1915-'17) a large steam-electric plant at Vasteros, in South Central Sweden. This serves as a reserve to the hydraulic developments to help them over peak periods and low water seasons, or in case of serious accidents, such as mechanical breakdowns. The plant is to consist of ten boilers with a total heating surface of nearly 65,000 sq. ft., of which only eight boilers had been installed up to 1926. Six can be fired with either coal or oil, two with peat, and one only with oil. The use of peat is most interesting and should be very economical, as huge deposits of good grade occur nearby and can be transported directly to the power-house quay. The operation of this plant shows how water-power development has reduced its importance recently, in spite of a steadily increasing use of electricity generally.

VASTEROS STEAM-ELECTRIC DEVELOPMENT

Years	*Maximum Load (Kilowatts)*	*Production (Kwt. Hrs.)*
1919	11,000	6,233,130
1920	15,000	7,914,450
1921	19,000	8,135,800
1922	21,500	1,820,050
1923	17,500	1,174,200
1924	12,800	755,100

For comparative purposes, data on the four big hydro-electric plants of the Swedish government are given in Table XXIX.

The very considerable fluctuation in flow of the above important power streams from year to year, as to both high and low water extremes, illustrates that the great reserve reservoirs of the forest humus and soil are really quite weighty matters to efficient hydraulic development, even in Sweden.

SOILS AS INFLUENCED BY FORESTS

Altho it is easy to catalog the apparent effects of forest upon climate, either locally or generally, and no one doubts that streamflow is intimately related to the character of growth covering the areas drained; yet it is difficult to prove these facts by actual measurements and many assumptions are debatable. But soils are far more definitely and certainly dependent on the forests. In fact, nearly all the world's agricultural soils are directly or indirectly of forest origin in whole or part.

The soils of such northern lands as Sweden have not only often been built of forest residues, but they are constantly being modified, favorably or otherwise, by the influences which trees exert thru their litter and roots. Some of these influences are universal in operation in all forests, but one in particular is practically limited to regions with a cold and humid climate. The phenomenon in question is best expressed in English by the word *podsolering,* derived from the Russian language [69–16]. It is the formation of a forest hard-pan or *ortstein* of German forestry. The formation is progressive and permanent, or nearly so. Its causes are not so well understood as to be definitely agreed upon by investigators. Certain basic facts in this connection are accredited as being responsible. The cold climate

TABLE XXIX.—Hydro-Electric Plants of Swedish Government

Location	Drainage area above Dam. (sq. mi.)	Fall Ht. (ft.)	Maximum Water-flow (gal. per sec.)	Minimum Water Flow (gal. per sec.)	
				Before Regulation	After Regulation
Trollhattan	18,142	103	211,000	84,480	*
Älvkarleby	11,194	53 to 65	554,000	21,120-31,600	35,640 to 52,800
Motala	2,432	48	14,500–29,000	2,900–11,350	†
Porjus‡	3,821	174†	260,000 to 390,000	6,600–7,920	10,560 to 13,200

Output—1924

	Maximum Load (Kilowatts)	*Total Production (Kwt. Hrs.)*
Trollhattan	113,500	724,162,000
Älvkarleby	63,000	251,708,000
Motala	8,200	49,761,000
Porjus	38,760	112,190,000

* Will later be considerably increased so the total power potential will be 300,000 Kwts. (425,000 h.p.) for the Göta River, on which this development is located.

† Will later be considerably increased.

‡ The Porjus site is capable of great expansion as a source of power. New dams have recently been built that will raise the low-water minimum to about 24,000 gal. per sec. and later construction projected will make the low water flow 42,200 gal.

is a factor in that it guarantees the seepage water, when it sinks down thru the upper soil and humus layers, is quite cold. This means that it takes up carbon dioxide more readily and carries more in solution than warmer water would. The large burden of carbon dioxide carried gives the soil water a high solvent power as regards carbonates especially. There is also an important factor in the various humic acids and associated organic compounds that develop steadily in the forest litter. They also heighten the solvent action of water and in course of time enable it to leach out nearly all the more soluble inorganic aluminum compounds in the upper mineral soil. The load of dissolved material, however, cannot, as a rule, be carried very far. The underlying rocks and mineral soils of the world are almost universally far less acid than the upper humus soil or vegetable litter. In many cases the underlying mineral soils are entirely neutral, due to the lime content of the rocks from which they are derived. The lime compounds possess a greater affinity for the acids and carbon dioxide, which the seepage water carries in solution, than do the compounds of iron and aluminum, which causes these latter to be precipitated, or deposited, in a horizon that tends with the passing years to become both thicker and denser. This soil horizon of deposition is darker in color than either the soil above or below, and is commonly rusty red to brown, so the name " rusty earth " (rostjord) is given it. This soil stratum varies considerably in color, consistency and thickness, as well might be supposed. It is at times so continuous, thick and dense as to be practically impervious to water. At other times, it is patchy and much broken. Its lower portion merges gradually, thru two to ten inches usually, over into the prevailing color of the deep mineral rocks and soil of the locality. The merging color is not always regular, but frequently shows dark and meandering vertical streaks where the seepage water has followed a certain course due to physical factors.

The enriched layer of rusty earth goes over rather abruptly above, as a rule, into a nearly white or blue to yellow-white layer of almost pure mineral earth. This stratum is differentiated sharply by color and other characteristics from the humus soil above it, as well as the rusty earth beneath. It is called (blekjord), " pale," or leached earth and is very low in content of soluble plant food or mineral compounds in general; so nearly free, in fact, that roots of most trees and plants try to avoid it.

The above described type of soil is more and more prevalent in Sweden from south to north, until it becomes practically universal in upper and inner Norrland. It also occurs in Central Europe at higher elevations and, sometimes, on the North German plain underlies large areas. Obviously it is in a great degree due to climatic conditions, but to an equal extent is determined by the character of the forest and its resultant litter. The forest litter is strongly influenced in manner and rate of decay by temperature and aeration of the soil. Both these factors are in a great measure affected by the presence and character of forests. In the latitude of Pennsylvania, if undrained mountain-tops be excepted, it may be said that detrimental raw humus never occurs; hence the formation of pronounced podsol profiles in the soil is rather rare. Further north they are common in America and in the Old World.

Table XXX gives an idea of the chemical constitution of the various layers in a typical podsol soil. It should be stated in passing that a certain rough homogeneity exists in these soils, both as to analysis and thickness of layers. The dark amorphous humus and mineral blended layer is one inch to three inches thick, as a rule.

The leached layer is about four inches thick when well developed, while the rusty layer is six inches to twelve inches through, and from analyses shows its enriched nature quite a distance below the colored horizon. This layer is naturally quite rich in certain plant food elements, as contrasted with strata above and below it. Roots would undoubtedly find a favorable zone in the rusty earth, were it less dense. This feature is somewhat variable and on the average is far less detrimental in Sweden than on the heath lands of Denmark and North Germany. There it causes much root deformation and inter-

TABLE XXX.—ANALYSIS OF A TYPICAL PODSOL SOIL [69–250]

Minerals	Leached Horizon	Underlying Soil
Quartz	55.8%	47.6%
Potash Feldspar	14.8%	15. %
Sodium Feldspar	16.6%	17.3%
Calcium Feldspar	9.2%	8.9%
Dark colored Minerals	3.1%	6.5%
Limonite (Fe_2O_3)	.1%	.7%
Apatite	none	.3%
Clay Compounds	.5%	3.4%

Compounds	Leached Soil Horizon (2-5 inches)	Rusty Earth Horizon (5-9 inches)	Underlying Soil (at 20 in.)
Fine material (2 mm. in diameter or less	79. %	71. %	76. %
Humus	2.15%	3.03%	1.17%
Water	2. %	4.27%	2.32%
Silica (SiO_2)	79.14%	70.28%	74.15%
Titanium Dioxide (TiO_2)	0.45%	0.44%	0.44%
Alumina (Al_2O_3)	9.21%	11.46%	10.82%
Silicaceous Fe_2O_3	1.12%	2.04%	3.24%
Limonite Fe_2O_3	0.13%	1.85%	0.64%
Lime (CaO)	1.77%	1.74%	1.86%
Magnesia (MgO)	0.52%	.96%	1.05%
Sodium Dioxide (Na_2O)	1.89%	1.62%	1.99%
Potash (K_2O)	2.41%	2.36%	2.45%
Phosphoric Acid (P_2O_5) Trace		0.19%	0.11%
Totals	100.79%	100.24%	100.24%

feres seriously with drainage and capillary action in the soil. Thoro investigations [69–242] on many Scandinavian forest sites indicate that it has rarely developed to a detrimental stage and is very slow in its evolution. A proper mixture of species and good silvicultural practices prevent it from becoming an evil. Moreover, on large areas of pine-heath, where moisture is the limiting factor to forestry, a podsol profile seems to be a positive benefit because it slows down the rate of water percolation and retains moisture for the use of the forest.

The chemical analysis of a podsol soil explains clearly just which compounds take an active part in bringing about the phenomena therewith connected.

A feature of Swedish landscapes and forest scenery generally, that has a certain relation to production of podsol soil, is the coloration of the water by humic acids. Wherever the soil is deficient in soluble lime compounds, the drainage water is more or less discolored. This is not so noticeable, or entirely undiscernible in spring water, but surface and subsurface run-off after rains show it very markedly. Just in proportion as the slowly decaying raw humus is more abundant, so the color of the water becomes more cloudy until it may appear coffee-brown from the leached out humic acids. When lime is present in the soil in soluble form, the humates are precipitated and the water that drains from an area is beautifully clear. The wonderful color of Lake Constance (Der Bodensee) in North Switzerland is due to the lime content of most of the soils in its drainage area. It is quite possible in Sweden, where forest humus is everywhere present, for one to merely look at the streams at high-water stages and get a fair idea concerning the available lime in the soils they drain. The hemlock and spruce woods of North America show the same coloration of the water in many localities where they prevail and have built up typical litter on the forest floor.

FLOODS AND EROSION

The sheltered locations and equable climate of Sweden have largely eliminated the flood and erosion problems that exist in many lands and are correlated more or less directly with deforestation and denudation by fire and grazing. No country shows such high and general appreciation of the evils of land clearing where the surface slopes considerably. It is very rare that one sees considerable slopes under cultivation anywhere in the whole long-stretched land. This fact and the character of the glacial soil and soil cover vegetation make muddy streams generally unknown; at least in the sense and to the extent we so commonly observe in the eastern U. S. The ridges and moraine land in Sweden, as well as the truly mountainous localities, exhibit gravelly or rocky, boulder-strewn conditions that make clearing nearly impossible and unremunerative from a cropping standpoint because of leaching and drying out of the surface strata.

Extensive regulation of the lakes and streams in Central and parts of North Sweden, for purposes of hydro-electric development, has raised many interesting and difficult questions with respect to the actual or imaginary ~~drainage~~ damage the forest may sustain from inundation over periods of variable length. Where great storage basins are established, or maintained, under control for equalizing stream flow, there is naturally considerable fluctuation in the level of these artificial lakes. This variable level, which is so definitely and necessarily associated with bodies of water commercialized for storage in water power projects is the great obstacle to contemporary inexpensive satisfactory recreational and æsthetic development. It means that unless vertical walls are built or steep banks are at hand, these storage lakes will be surrounded by a greater or less wide belt of unattractive waste land at times of low water. It is also inseparable from the nature of things that deep rooting species may be killed back quite a distance from the high water limits of these lakes, or in some other cases may be detrimentally reacted upon by changed and varying ground-water relations. The stream regulation work in the above connections has been quite extensive in Sweden, and dates back twenty years or more on certain sites. Observation and investigation of the phenomena have been long under way, and an interesting mass of data is available for the species and soil conditions that prevail there. It is not within the limits of a discussion on forest influences to enter into the details of forest damage from inundation, but it is again emphasized that a forest cover, on steeper sites especially, has an important and very efficient power respecting water storage. This capacity of a forest soil to store water makes the construction and use of artificial dams and regulatory works less important where the tree growth is carefully maintained or re-established. The necessary fluctuations in level of the dams constructed for a given power development is also less if the character and density of vegetative cover in the drainage basin can be improved.

The silting up of regulatory basins is not rapid in Sweden; in fact, very slow, compared to the case in the U. S. A. generally. Yet even in Sweden, the bearing of the forest upon the power problem from all the foregoing angles is so well recognized, that care and protection of the forest gained in public and private importance in proportion as electricity become more commonly used for power and to banish the solemn and discouraging gloom of the long, cold winter when daylight and sunshine are nearly or quite extinguished.

TIMBER-LINE FORESTS

The meager and distorted, or even dwarfed, stands that fringe the far north and high limits of the Swedish forests are more important than may appear at first thought. This sparse and slow-grown birch, or spruce, with scattered pine, is the wall that protects the better forest behind and below it. With the dense moss or lichen and lowly shrub ground-cover at hand, it becomes the home and shelter of many forms of wild life, especially birds, that breed during summer in these secluded regions. In winter the reindeer and other boreal game find food under the characteristic low spreading birch growth.

Its abuse or destruction always puts a penalty upon the forests and wild life of adjacent localities.

The timber-line thruout Scandinavia is being slowly but surely beaten down. Remains of big logs and stumps are found on bare land now well above even the scrub growth of the forest margin. A cooler climatic cycle is the only sufficient explanation offered for this retreat of the forest.

RECREATION

Many of the typical Scandinavian sports are inseparable from a forest environment. The most general one is ski-running. This has been developed to a far greater extent in several European lands than in America. Here, by tradition and custom, the snowshoe is preferred when speedy travel over deep snow is in question. It is hard to decide the relative merits of the light but broad and flexible American development as compared to the long, narrow but stiff ski. Both require skill to handle them most effectively and excel in certain respects. Ski-jumping and sledding over icy roads in the wake of a sharp-shod horse have no special connection with the forest, but the adeptness of a trained ski-runner in crossing great stretches of wooded terrain at high speed is almost unbelievable when one recalls the obstacles and pitfalls to be avoided. Races over a given course are common in Sweden. Some of these contests are national events and even date back to historical incidents. The best example in this connection is the "Vasa course" over the route run by the hero-king, when he decided to espouse the cause of freedom. Skiing in an open country would be tame and colorless, contrasted to its charm and problems in a forested land.

"Orientering" is another type of Marathon-race popular in Sweden and unthinkable except where forest growth dominates the landscape. The competitors in this sport are permitted to equip themselves with a compass and general map of the region in which the race is to be staged. They are then taken to a starting point in some remote and relatively inaccessible locality, presumably unfamiliar to all contestants. The objective or winning point is then announced by the starters, who may themselves not know it until sealed instructions are opened. The contestants then run by the most direct or best route to the goal given them.

The forest is highly beloved by the Swedish people, and they take full advantage of its beauty and delights during the all too short but most lovely summer. Family parties and neighborly picnics are the constant order of the day when leisure is at hand. Houses are abandoned in so far as possible and life in the open, both day and night, is often the rule. No one will eat indoors if it be possible to do this out under a tree or in the adjacent woods.) This custom of making the fullest use of the open air when weather is fair, doubtless accounts in large measure for excellent public health in spite of adverse climatic conditions; considering the year through, and some customs that run counter to modern ideas of hygiene and sanitation.

TOURIST TRAFFIC

The fjords of Norway and North Cape with the " Midnight " sun have long been world-famous, but the attractions of Sweden have only recently begun to be appreciated by the globe-trotting sightseer. Any one who visits this land will forever recall its charm with keen regret that time limited their stay there. No country so grows upon the visitor who sees it for the first time, and the greatest of all the factors that account for the effect is the forest. In Sweden the woods give an impression of order without the stiffness characteristic of German forests. Waste and ugliness never shock the senses. The forest is beautiful, friendly and sheltering in prospect. The variety shown is not so great as in some few sections of America, but is still quite remarkable when the small number of component tree species is remembered. The forests of Sweden frame every view, they give the traveler some surprises and much pleasant satisfaction. They cannot fail to make the land in the near future famed for both summer and winter interest.

LITERATURE AND ART

The forest is interwoven thru the best of all artistic productions of Scandinavia. The folk-lore and early writings constantly refer to forest scenes and incidents. Wood-land motifs and trees characterize not only the painting, poetry and prose of these people, but permeate all their most notable decorative effort. The handicrafts constantly go to the things of the forest for models and inspiration. The art of wood-carving is probably as well developed in Norway and Sweden as anywhere else.

ETHNIC INFLUENCES

The extensive use of wood in building is to be expected where forests are everywhere at hand. This has been a blessing to the people in respect to health and welfare generally. Hovels of dirt, sod or stone, tents of skin or cloth are not sufficient protection to the human body to permit of activity or promote mental processes in cold climates. They tend to encourage alternate gluttony and " *hibernation* " during the long cold season. They are relatively too small in size with primitive folk to induce efforts toward self-improvement. Wood, however, is bulky and rather easily worked, as well as highly non-conductive. It encourages more commodious building and better construction. Thus the forest and use of wood may go far to account for the progress of Nordic peoples of the white race in contrast to the Lapps and most other Mongolians.

The early Norse folk were a hardy and vigorous stock. Their long centuries and generations of life in the forest, which preceded adventuring on the seas, undoubtedly deserve much credit for the physical, mental, moral and social development registered.

CHAPTER V

IMPORTANT FOREST REGIONS AND TREE SPECIES

SWEDEN divides naturally into three regions with respect to the distribution of tree species. (1) In the north the conifers and birch (two forms of *Betula alba*) reign supreme. In addition to these there are only occasional specimens or clumps of European aspen (*Populus tremula*), and in moist places where the acidity is low, possibly gray alder (*Alnus incana*) may be met. There are quite a few low boreal shrubs also at hand, especially on sites where climate or soil are not sufficiently favorable to permit forest growth. Two species of birch and more than ten willows can be identified among these dwarf woody plants that battle bravely with the Arctic winds and ice. One of the smallest representatives of these genera which we are accustomed to think consist essentially of trees, is *Salix herbaceæ*. It very rarely exceeds an inch or two in height and may be easily overlooked among the mosses and lichens with which it associates. (2) In middle Sweden, the stalked oak (*Quercus pedunculata*) and certain other of the so-called " Noble leaf-trees " have their botanic range, but possess little or no economic or commercial importance. (3) In the south the oak and other hardwoods really grow quite well and are worthy of practical consideration, even if the present tendency is to replace them with planted stands of spruce. This is commonly designated the " Beech forest region." It includes that part of the country below the latitude of Karlskrona, the southern half of the island of Öland and the south-west coastal slope nearly up to the Norwegian boundary. Oak and beech stands once probably dominated here, but only scattered remnants exist today [16–25].

THE NORTHERN CONIFEROUS REGION [40–12]

This caption covers much the greatest area of Swedish forests. The cultivated soil varies from ½% in Norrbotten province to 4% for Västernorrland. Only in a relatively small portion at the south, Dalarna, does the area cultivated rise to 20% or 25%. The area of hay and pasture land varies from less than 1% up to nearly 3%. The rest of the land supports an unbroken forest except where bogs and rocky cliffs or alpine areas intervene. These, however, make up a considerable total and vary by provinces from 7% at the south to 58% in Norrbotten. Moreover, it is here that forest stands are most likely to suffer from " drowning out " due to rising of the water-table. Drainage work is needed to merely maintain the forest in *status quo,* but comprehensive drainage projects can win a vast acreage to productive use.

Toward the north and at high elevations conifers give away to the alpine birch stands that characterize timber line. The pine usually goes up higher than the spruce or shows better stature and higher growth-rate at the coniferous limit. The birch stands are crippled and gnarled or grotesque in aspect and become progressively reduced in size and thrift of trees until the tundra-like areas of low-Arctic vegetation replace the last straggling, fighting pioneers of the forest. In a few rare instances the alpine birch stands are lacking and conifers form the timber-line growth, but in most alpine localities this high mountain hardwood type is quite extensive and important as a source of fuel to the Lapps and the industrial population that is developing the mineral and water resources at several points in these inhospitable tracts. In Norway this forest type has still greater significance since it is not so sensitive to the effects of the ocean winds as conifers are. Aspen, gray alder and mountain ash are at times met in these universally predominant birch stands.

At the south this region is limited by a very irregular line from Lake Vänern to a point north of the mouth of the Dal River.

THE SOUTHERN CONIFEROUS REGION

Between the limits heretofore set for the Northern Forests and the Beech Region lies the locality of most extensive cultivation and industrialization,—the Southern Coniferous Region. Its forest stands are broken by fields and meadows. Conifers dominate; pine developing especially well, but the broadleaf trees also play a considerable rôle in certain localities. Oak groves occur occasionally and on better soil, ash, elm, linden and Norway maple, are met here and there at lower elevations. The bounds of this region on the south and southwest are about the natural limit of the range of spruce.

THE BEECH REGION

No natural coniferous forests were original to this rather limited region. The oak and beech stands that remain are but scattered residual vestiges of the hardwood growth which fell before the steady progress of agriculture. Cultivation is very intensive as a rule, except where the soil has been so extremely impoverished by centuries of destructive grazing with nearly annual fires. Under these conditions there have developed large areas of sterile heath-clad ridgelands, where reforestation is often extremely difficult. Records and tradition show that these absolutely waste areas were once covered with splendid forests of oak, which served as the basis of the shipbuilding that characterized South Sweden for centuries during the late Middle ages. Here the sugar beet is an important money crop, and wheat yields well. Often willow and poplar pollards along the roads, fences and water-courses are the only trees that relieve the monotony of the countryside when one gets away from the immediate vicinity of human habitations with their garden and shade trees. Pollarding is esthetically indefensible, but in densely populated sections where grazing of roadsides and fields is continuous and important to agricultural economy, it serves a very useful purpose. Most of the fuel used on many South Swedish farms is secured from periodic top-lopping of these abused and deformed sentinels of the wayside. In a land practically devoid of coal and locally completely deforested, the fuel problem demands solution. Pollards help considerably, as they yield wood at the same time they permit the cheapest and most efficient harvesting of a grass crop from the same soil. Lopping of branches occurs at intervals of two to five years. In some instances the cut surfaces are protected against decay by painting.

The planting of Norway and white spruce, as well as pines, has redeemed a quite large aggregate area of heath and sand-dunes in this region. The growth made by spruce on some of the old heath lands is simply amazing, and furnishes a striking example of the economic advantage of intelligent forest extension. Table XXXI sets forth the increment and growth on a site that, due to abuse, was no longer worth while as pasture. Heather (*Calluna vulgaris*) dominated the area in company with sparse and dwarfed plants indicative of soil acidity and sterility. The details in this table are cited at length because they give a very good example of rational thinning in planted Norway spruce on a favorable site,—for such it certainly has proven to be since the stand has become well established. Increment on these sample plots is equal to any that can be quoted for the species further south, where growing seasons are longer. A rate of growth in excess of 300 cu. ft. per acre per year is irrefutable testimony to the natural fertility of a soil which, prior to planting, was absolute waste land.

SWEDISH FOREST TREES

Scotch Pine *(Pinus sylvestris)* [40–59]

The common pine of Europe occurs thruout Sweden, but was originally rare or absent at the extreme south. It is the most important forest tree of the country, but does not now hold the preëminence in the forestry world it once had. The pulp and paper industry has made the growing of spruce increasingly advantageous, so forest managers no longer strive to favor the pine to the exclusion of spruce, except on sites ill adapted to the latter. Pine has been, and will probably ever remain, the backbone of the lumber industry in Baltic lands. There are many poor dry sites on which it grows well while spruce languishes. On all soils it will attain a given merchantable size at an earlier age than its more tolerant associate,—the advantage being in inverse ratio to site quality.

It is well known that this pine shows extreme variation in growth habit and features generally, when specimens from different parts of its range are compared. In Sweden no such poor strains of the tree occur as are found on the Prussian plains and in the Rhine Valley,

TABLE XXXI.—DEVELOPMENT AND INCREMENT OF NORWAY SPRUCE PLANTED ON WASTE HEATH LAND IN SOUTH SWEDEN
Thinning Series—Skogsförsöksanstalten [60–18]

Age of Stand (yrs.)	Stand after Thinning					Thinnings Removed						Total Yields		C. A. I. since Last Thinning					M. A. I.	
															S. A. per A.		Vol. per A.			
	Trees per A.*	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	Trees per A.	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	% of Stand	Vol. per A. (cu. ft.)	Thinning %	Height (ft.)	Sq. Ft.	%	Cu. Ft.	%	On Stand after Thinning (cu. ft.)	On Total Yield per A. (cu. ft.)
Plot I—(Check) Cleaned of Dead and Dying Trees																				
31	1564	182.5	4.6	35.0	3632	882	14.1	1.7	21	172	4.7	3804	4.7						117	123
37	1377	207.2	5.2	45.5	5692	186	7.7	2.8	28	129	2.3	5691	5.4	1.64	6.9	3.3	310	6.8	145	153
42	1245	230.8	5.8	50.0	6392	132	7.7	3.3	32	128	2.0	6821	6.4	.92	4.8	2.1	232	3.9	152	163
46	1150	238.4	6.1	54.4	6950	93	6.9	3.7	37	129	1.9	7522	7.5	.75	3.6	1.5	173	2.6	151	164
Plot II—Light Thinning from Below																				
31	1275	171.3	4.9	35.7	3446	637	14.2	2.0	24	200	5.6	3646	5.6						111	118
37	1118	199.9	5.7	46.5	5034	167	10.3	3.4	31	186	3.6	5420	7.2	1.64	6.5	3.4	296	6.8	136	147
42	959	204.6	6.2	51.7	5749	148	20.1	5.0	45	472	7.6	6607	13.0	.92	4.9	2.3	236	4.2	137	157
46	843	203.3	6.6	55.2	5934	115	15.2	4.9	49	400	6.3	7193	17.5	.66	3.5	1.6	145	2.4	129	156
Plot III—Heavy Thinning from Below																				
31	1202	164.1	4.9	35.7	3303	1135	36.6	2.4	28	601	15.4	3904	15.4						107	126
37	980	188.9	5.9	46.8	4776	221	23.0	4.4	35	443	8.5	5820	18.0	1.90	8.0	4.2	318	7.5	129	157
42	807	187.2	6.4	52.4	5291	173	31.6	5.8	50	815	13.4	7150	26.1	.98	3.9	2.9	267	4.9	126	170
46	635	173.2	7.0	56.3	5391	172	31.6	5.8	52	915	14.5	8180	34.0	.82	4.5	2.3	256	4.4	117	178
Plot IV—Heavy Followed by Very Heavy Thinning from Below																				
31	1091	161.9	5.1	41.0	3289	720	25.0	2.5	29	415	11.3	3704	11.3						106	119
37	925	190.8	6.1	47.2	4819	167	15.2	4.1	33	286	5.7	5534	12.8	1.71	7.4	4.0	305	7.3	130	149
42	627	160.3	6.8	53.0	4547	298	59.1	6.0	50	1544	25.4	6807	33.2	.82	5.6	2.7	256	4.7	108	162
46	418	132.4	7.6	56.3	4176	209	46.9	6.4	53	1401	25.1	7836	46.7	.66	4.7	2.8	257	5.0	91	170

*All data is on an acre (A.) basis.
S. A. signifies the cross-sectional area sum for all trees on an acre taken 4½ ft. above the ground.
C. A. I. = Current annual increment.
D. B. H. = Diameter at breast height (4½′)
M. A. I. = Mean annual increment.

but there does exist a vast difference between the pine of Norrland and that of the Southern Coniferous Region. Some of the world's best authorities in the field of forest botany [34–348] have maintained a separate specific status (*P. lapponica*) for the northern type. This contention is, however, quite untenable when we note the even transition of one form into the other in the tension zone where they meet. The pine of South Sweden is also quite different from all Central European forms. It can even be readily distinguished from the famed Riga variety when in the first year seedling stage, altho the two are native to localities climatically very simliar. The shorter needles of the boreal races is always a notable feature. After the juvenile stage of life is past, the short and numerous but light side branches, and excellent form habit are typical of the northern pine except under extreme conditions.

Undoubtedly in the above mentioned variations we have one of the best illustrations of the inheritance of acquired characteristics. The pine has migrated into the north since the Glacial Era and, after many successive generations, numerous advantageous adaptations have made their cumulative impression upon the germ-plasm, so that many but not all the acquired characteristics have come hereditable, regardless of the climatic conditions where the offspring of these trees may now develop.

One of the non-hereditary features of the North Swedish pine is its root system. In the cold north, where the soil may not become completely thawed out in summer, and at best is always cold except superficially, this tree loses its typical tap-root and develops quite a rambling and rather shallow system. Seedlings of such trees, however, develop tap-roots when grown in warmer localities. The development of the roots is always to a degree adapted to site and age. Older trees show relatively much stronger tap-roots as compared to their laterals than do young ones. On sterile, sandy or highly acid soils the root-system tends to be flat, while on better soils it is more concentrated.

The shorter needles and more slender habit of this tree toward the north sometimes gives it a striking resemblance to the northern jack pine (*P. banksiana*) of America. Under adverse climatic conditions it fails to develop the regular whorls of lateral branches that are characteristic further south. It also grows more slowly and retains its needles until the eighth or ninth season. All these features together render the Norrland pine very similar in appearance to the jack pine of Canada and quite unlike the forms met further south. In Middle Sweden the pine rarely retains its needles longer than the third season.

"German pine" is a designation full of opprobrium applied to such planted trees in Sweden as have originated from imported seed usually collected in Central Europe. Trees from seed of such southern sources show almost without exception very poor stem-form and long heavy branches. On poor sites and in exposed locations, boles are short, crooked and knotty. As a rule, such trees yield little or no viable seed and are highly liable to damage by fungi and climatic agencies.

In the matter of seed origin for use in artificial regeneration in Sweden, some very thorough experiments have been carried on by the Forest Experiment Station [56–307 and 14–59]. These relate especially to pine, as it is generally admitted that European spruce (*Picea Abies*) is quite constant in its habits of growth, regardless of seed origin. Pine exhibits amazing variation in respect to ability to grow and thrive within rather limited regions. Pure seed from even so far north as Dalarna in Central Sweden is doomed to failure in Lappland. It has been found that the average temperature during the growing season, June to September, inclusive, is very important to the thrift of pine. When Sweden was carefully divided into zones of equal growing season temperatures with intervals of one degree centigrade (1° C.), it was found by actual planting experiments that seed could only be successfully transferred and planted in the next adjacent colder zone. When it was transferred across a zone into the second colder one, the resultant seedlings grew very poorly and were especially subject to death and damage from the snow shedding disease (*Phacidium infestans*) and other fungous troubles, as well as direct climatic influence. Northern grown seed, on the other hand, grew well when transferred southward almost without limit; somewhat slower development being the only noticeable reaction when transfers were made to much warmer zones. Transfers of seed to zones only one or a few degrees warmer, resulted in very thrifty, vigorous-growing seedlings that, as a rule, surpassed the offspring of local trees themselves. These experiments tend to demonstrate the general validity of the claims commonly set forth for "northern grown seeds" in agriculture and gardening.

Seed of northerly origin is notable for a quite high percent of delayed germination, varying considerably from year to year for a given locality and also for a given year between adjacent localities. This feature of germination was studied carefully by Wibecke [76–1], who came to the conclusion that failure of pine seed to grow during the first season after maturity was not essentially due to heredity, but to temperature and possibly weather conditions generally during the growing season when the cones matured. Low temperatures or an unusually short vegetation period causes the seed embryos to develop incompletely in many instances. Apparently, germination of seeds is impossible, regardless of the favorable character of exterior factors, unless the embryo within the seed has attained a certain size and ability to function. Two samples of fresh seed were examined microscopically after being tested for germination. One sample was collected in Central Sweden and showed 5% of sound seed that failed to grow, while the other from the far North showed 90% delayed germination. The embryos of the southern seed were from 43% to 92% as long as the kernels in longitudinal section and averaged 76%, while those of the northern sample varied between 19% and 89% as long as the seed kernel and averaged 63%.

From the above, it is logically assumed that the partially developed embryos of the seed from far north possess great latent vitality, enabling them to undergo a certain intra-seminal evolution during the season following their separation from the mother tree. This permits active growth the succeeding season.

Pine in Scandinavia and the East Baltic lands has relatively thin bark of a redder or lighter color than the tree exhibits further south.

Pine is noted in Sweden for its adaptability as regards site, from both soil and climatic standpoints. It occurs on deep fertile loams and pure sands, on moraines of tumbled rock fragments and gravel, as well as on the strictly vegetable strata of deep bogs. In many localities it goes higher on the mountains and further north than spruce. Its extreme outpost in the latter respect is 70° 20′ North Latitude in Finmark, Norway. On the mountains of North Sweden it ascends to 1,310 feet, and in the southern part of the country its limit varies between 2,625 and 2,950 feet above tide.

Direct seeding usually, in prepared spots, has always been a popular reforestation method in Sweden. Pine, with its marked intolerance of shade and rather rapid height growth in early life, has been quite well adapted to this practice.

The data in Tables XXXII and XXXIII show definitely how rapidly pine stands develop in different regions of Sweden where sites are favorable.

Where Swedish forests are reproduced naturally, as is prevalent northward, clear-cutting silviculture always dominates where it is desired to favor pine at the expense of spruce. This is also true to the south, where a combination of N. S. R. and spot seeding is often practiced. Seed-trees are left almost invariably, even if nursery grown seedlings are to be planted on an area, it is not unusual to see two to four choice straight trees present per acre to complete the regeneration and improve its quality. In order to further favor pine it is often the custom to broadcast-burn the brush and litter or débris on recently lumbered sites; precautions being taken to protect any seed-trees left and to restrain the fire from spreading to adjacent stands.

Many of the best stands of pine in Scandinavia originated after forest fires, which were permitted to burn at large as late as the early nineteenth century, or as a result of the so-called " Finnish practice " (Finska-bruk) of temporary or peripatetic agriculture. These clearings by use of fire were usually not very extensive, or were incomplete and left pines of seedling size standing about in sufficient numbers to re-establish a new stand of satisfactory sort.

Cones and seeds of (*P. sylvestris*) the common pine of Europe are just as variable as its other features; especially as to size, weight and color, the seeds exhibit considerable range, as partially illustrated in Table XXXIV. The color of seed is generally a fair criterion of its germinative energy. The greater the proportion of the dark seeds as

TABLE XXXII.—PINE STANDS ON JÖNOKER COUNTY FOREST (SOUTH SWEDEN), THINNING STUDY

Age of Stand (yrs.)	Stand after Thinning					Thinnings Removed						Total Yields		C. A. I. since Last Thinning					M. A. I.	
	Trees per A.	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	Trees per A.	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	% of Stand	Vol. per A. (cu. ft.)	Thinning %	S. A. per A.		Height (ft.)	Vol. per A.		On Stand after Thinning (cu. ft.)	On Total Yield per A. (cu. ft.)
														Sq. Ft.	%		Cu. Ft.	%		
									Plot I—Light Thinning from Below											
29	1329	88.9	3.5	31	1462	431	5.2	1.5	21	71	4.7	1553	4.7						50	53
34	1187	103.5	4.0	32	1719	142	3.5	2.1	25	53	3.0	1843	6.8	3.6	3.7	.2	61	3.8	50	54
40(c)	742	87.3	4.6	41	1773	470	34.7	3.7	33	599	25.2	2496	29.0	3.1	2.7	1.1	108	5.3	44	62
46	637	89.4	5.1	43	1936	104	8.5	3.9	33	146	7.	2805	31.0	1.8	1.9	.3	51	2.7	42	61
									Plot II—Heavy Thinning from Below											
29	1097	84.7	3.8	31	1400	631	13.4	2.0	26	206	12.8	1606	12.8						48	55
34	953	99.5	4.4	33	1665	144	4.7	2.4	26	74	4.3	1945	14.4	3.9	4.2	.3	67	4.3	49	57
40	648	87.2	5.0	42	1812	357	33.6	4.1	37	617	25.4	2709	33.1	3.5	3.2	1.2	127	6.2	45	68
46	486	76.5	5.4	44	1682	162	21.8	5.0	42	459	21.4	3038	44.6	1.9	2.0	.3	54	2.8	37	66
Plot III—Very Light Thinning from Below Followed by Crown Thinning at 40 and 46 yrs. of Age to Favor Spruce Understory																				
29	1929	98.4	3.1	30	1593	433	4.5	1.4	22	63	3.8	1656	3.8						55	57
34	1727	114.1	3.5	31	1873	202	5.1	2.3	25	79	4.0	2015	7.	4.2	3.8	.2	72	4.0	55	59
40(a)	563	66.6	4.6	41	1366	560	46.7	3.9	37	853	38.4								34	
40(b)	452	15.8	2.5	29	256	153	5.8	2.6	29	97	27.5								6	
x	1015	82.4	3.9	39	1622	713	52.5	3.7	36	950	36.9	2714	40.2	3.5	2.8	1.0	116	5.2	41	68
46(a)	344	58.1	5.6	44	1276	219	17.9	3.9	38	340	21.8			1.6	2.2	.3	42	2.8	28	
46(b)	369	15.8	2.8	29	286	82	3.2	2.7	30	56	16.3			.5	3.	.1	14	4.8	6	
x	713	73.9	4.4	41	1562	301	21.1	3.6	36	396	20.2	3050	48.8	2.1	2.4	.2	56	3.1	34	66

(c) 62 small spruce measured and added at 40 yrs. of age.
(a) = Data for pine, (b) = data for spruce, x = total. No distinction made earlier.
Note:—Snow damage caused all later thinnings to be heavier than needful.
Unexplained abbreviations in this table are the same as used in Table XXXI.

TABLE XXXIII.—PINE IN MIDDLE AND NORTH SWEDEN—THINNED HEAVILY FROM BELOW
(All data on per acre basis)

Age of Stand (yrs.)	Stand after Thinning					Thinnings Removed						Total Yields		C. A. I. since Last Thinning					M.A.I.
														S. A. per A.			Vol. per A.		
	Trees per A.	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	Trees per A.	S. A. per A. (sq. ft.)	Average D. B. H. (in.)	Average Height (ft.)	Vol. per A. (cu. ft.)	% of Stand	Vol. per A. (cu. ft.)	Thinning %	Sq. Ft.	%	Height (ft.)	Cu. Ft.	%	On Total Yield (cu. ft.)
Plot I—Sample Area on Öns Crown Forest, Middle Sweden (Pure Pine)																			
75	1021	131	4.8	51	3374	807	36.1	2.9	42	815	19.5	3941	19.5						56
80	643	118	5.8	53	3115	377	26.1	3.5	45	617	16.5	4216	31.5	2.48	1.8	.13	72	2.0	57
86	481	101	6.2	58	2927	162	28.9	5.7	54	792	21.3	4798	43.2	2.05	1.7	.66	101	2.9	60
92	279	82	7.3	63	2528	203	38.1	5.9	55	1026	28.9	5366	56.3	3.22	2.9	.43	104	3.2	63
Plot II—Sample Area on Haverö Church Forest, Middle Sweden (A few spruce and alder are mixed with pine)																			
80	563	161	7.2	62	4917	1012	53.0	3.1	48	1056	17.7	4189	17.7						75
84	428	152	8.1	67	4859	135	16.8	4.8	51	455	8.6	4547	23.7	2.09	1.3	.49	99	1.9	76
90	354	141	8.5	70	4744	74	24.7	7.8	69	816	14.7	5151	32.9	2.27	1.4	.49	117	2.2	79
96	244	123	9.6	74	4299	110	36.2	7.8	68	1133	20.9	5779	44.6	3.01	2.0	.49	115	2.3	81
Plot III—Sample Area near Alträsket on Crown Forest in North Sweden (A few birch are mixed with pine)																			
84	512	103	6.1	52	2947	474	30.3	3.4	43	713	19.5	3660	19.5						44
91	371	94	6.8	57	2802	140	18.9	5.0	47	483	14.7	3998	29.9	1.31	1.2	.46	48	1.6	44
96	302	83	7.1	59	2553	69	20.3	7.3	60	626	19.7	4374	41.7	1.92	1.9	.39	76	2.5	46
Plot IV—Sample Area at Statträsket on Crown Forest in North Sweden (Pure Pine)																			
59	1465	134	4.1	41	3002	1962	31.6	1.7	26	496	14.2	3498	14.2						60
66	821	114	5.0	44	2733	644	36.3	3.2	33	670	19.7	3900	29.9	3.92	1.7	.13	57	1.8	59
71	630	97	5.3	46	2415	191	28.6	5.2	45	686	22.1	4267	43.4	5.23	1.9	.26	73	2.5	60

Note:—This and similar tables embody data from fully stocked areas of site quality I or II for the locality. By comparing data for the two different localities covered by Table XXXIII, it will be seen that pine yields more than 30% better in Middle than in North Sweden. Abbreviations in this table are the same as used in Tables XXXI and XXXII.

compared to the yellow or gray and mottled, the better the given sample of seed. Cones vary both in size and conformation. The tendency being for cones to be smaller in the colder regions of the tree range. A bushel of cones may contain from 1,760 to 10,560 cones, dependent upon its origin. Older trees in any given locality bear considerably smaller cones and seed than do younger ones.

Good seed-years of pine occur in South and Central Sweden at intervals of four to six years, in the forests of Norrland at intervals of eight to ten years, but from fifty to one hundred years may elapse between years of abundant seed-bearing in timber-line localities on high mountains and far north.

TABLE XXXIV.—Size and Weight of Pine Seed in re Locality and Age of Mother Trees [74–412]

Locality	Age of Trees (yrs.)	Number of Seeds per Pound
Germany	?	87,000 to 96,000
Central Sweden	?	91,000 to 113,500
North Sweden	?	150,000 to 375,000
East Jämtland (Middle Sweden)	50	148,000
East Jämtland (Middle Sweden)	70	178,000
East Jämtland (Middle Sweden)	100	200,000
Tjust State Forest (S. E. Sweden)	60–80	102,000
Tjust State Forest (S. E. Sweden)	80–120	111,000
Tjust State Forest (S. E. Sweden)	120–150	118,000

The weight of Swedish pine in air dry condition varies between 22.5 and 46 pounds per cu. ft. In any particular bole the wood is heaviest near the base and decreases upward in quite even ratio. Wikjander found that pine wood from Norrland was weaker and 10% to 14% lighter in weight than that from Central and South Sweden, in spite of showing many more annual rings per radial inch due to slower growth.

Among the most serious enemies that attack pine in Baltic lands are the below listed fungi and insects:

Shedding disease (*Lophodermium pinastri*) is deadly to pine seedlings when they stand close in seed-beds under warmer climatic conditions. This trouble has never been so serious in South Sweden as in Central Europe, and further north is unknown. The specific remedy applied in nursery practice is Bordeaux mixture. Where the disease is to be feared, the forest nursery should be isolated from stands of pine, especially those of youthful age, and pine needles or brush should never be used to cover seed beds.

The snow shedding disease (*Phacidium infestans*) is a needle trouble that has worked havoc in many forest plantations of pine in Norrland. It seems to be an unknown form in America and should be carefully guarded against, as it is very serious in the seedling and sapling stages of this conifer wherever severe winter climate occurs.

" Brittle disease " (*Melampsora pinitorqua*) has an alternation of generations between pine and the aspen (*Populus tremula*), a tree very like the American species (*P. tremuloides*). This rust attacks the new shoots of pine and causes a canker-like development, weakening the growth so the shoot breaks off or is bent down and afterward grows upward so as to show an S-shaped crook. The trouble from this fungus is at times considerable in young, even-aged pure stands, especially if occasional aspen sprouts or larger trees are present.

Pine canker (*Peridernium pini* or *Cronartium asclepiadeum*) occurs universally thruout the native range of Scotch pine, but varies markedly in local prevalence. It does not usually attack trees until they are forty to eighty years old, when it often besets the best trees of a stand. The characteristic cankers or " cat-faces " develop rather slowly and are the source of the rich-pine or " light-wood " used by forest folk of the Old World as torches and for kindling.

Two species of *Dasyschyfa,* as well as *Crumenula pinicola* and *Lachnella* sp., are causes of canker-like wounds on pine and are likely to be most troublesome where pine is growing under unfavorable conditions.

The honey fungus (*Armillaria mellea*) attacks the roots of pine, especially during its younger stages, and causes a characteristic concentration of resin at the root-crown. The root-rot of conifers (caused by *Polyporus radiciperda*) spreads underground in the same way as the honey fungus, and often infects a promising young plantation from the mycelia and spores developing on old beech, oak or birch stumps nearby. Ditching at a sufficient distance from the source of infection is the only remedy known, and in this work care must be taken to cover with earth all ends of cut roots on the inner bank of the isolation ditch and otherwise eliminate all possibility of spores being borne on the decaying 'roots and stumps.

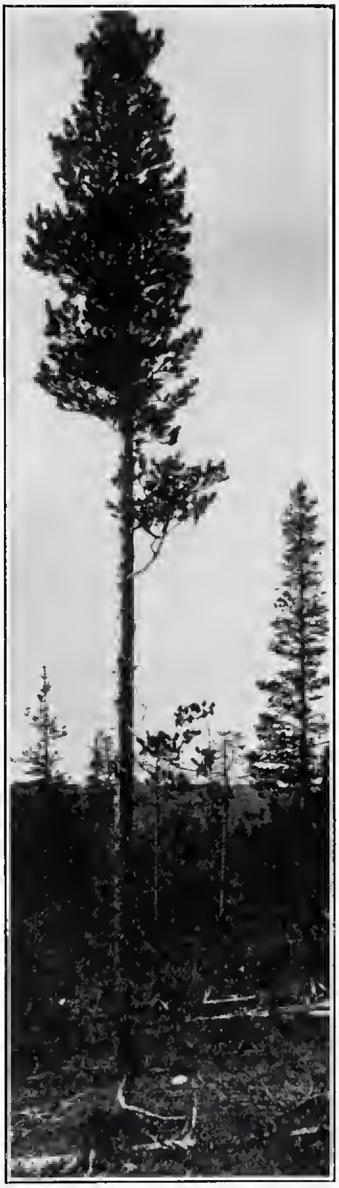

FIG. 5.—TYPICAL FORM OF SCOTCH PINE IN THE FAR NORTH.

Pine has a dense conical crown of small, short branches in these regions of heavy and persistent snows. It also grows very straight and exactly upright.

Among insect enemies of pine, the most serious in Sweden, generally, are the snout-bugs (*Hylobius abietis* and *H. pinastri*). These, when full grown, bore into the thin bark of younger trees and eat the cambium tissues. Larvæ develop in the wood of stumps and larger offal from lumbering. They are relatively harmless or even beneficent in their activities. The adults, on the other hand, may ruin young reproduction and trees in nursery beds. Ditches with steep banks have been used in Germany to protect such essential areas. In Sweden trap-ditches and pieces of bark are arranged so the insects can be collected and killed. The pre-war price paid for such work was twenty-seven cents per thousand bugs collected. A quart measure will contain nearly 3,000 of the insects.

The pith-borer (*Myelophilus piniperda*) has its larvæ stage as a bark borer in dead or recently felled logs, cord-wood or débris, but occasionally attacks old and slow-growing living trees. The adults eat into and destroy the pith of pine twigs and shoots, causing them to die or break off and drop to earth. Trap-trees are most serviceable in checking epidemics of this insect, but good sanitation in the forest with the barking of all wood that is to lie over summer in the forest are effective preventives.

Among the saw-fly forms that attack pine in Sweden *Lophyrus pini* and *L. certifera* are most detrimental. *Lyda* sp. also do some damage.

The pine shoot and bud borers (*Evetria bouliana, E. resinella* and rarely *E. turionana*) at times much disfigure and deform the crowns of young trees.

The nun-moth (*Lymantria monacha*) and some related forms have occasionally done considerable injury to pine in South Sweden in limited localities. Northward they are unknown or harmless. The nun only eats pine in default of spruce and cannot thrive on its needles in Sweden.

The pine louse (*Lachnus pini*) at times does injury to pine on poor, dry sites, especially during seasons of little rainfall and warm weather.

Scotch pine, in the extreme northern portion of its range, reacts somewhat differently in respect to the factors of site than it does southward. Thus intermixing pine with broadleaf trees or Norway spruce and covering the soil with heavy layers of brush seem favorable to increment and thrift of the tree in Germany. This is true, also, in South Sweden, but in Norrland the temperature of the soil is probably usually the limiting factor and such silvicultural treatment as permits the sun to heat up the soil in summer is apparently most desirable. The more thrifty and vigorous the growth pines may be enabled to make, the better able they are to resist the ravages of the fungi and insects that prey upon them.

The Swedish Forest Experiment Station estimates that there are about 28,500 acres of pine plantations in Sweden that originated from Central European seed. These stands not only yield crooked and knotty timber under the most favorable conditions, but are likewise especially liable to damage from all the fungi and most of the insect agencies listed heretofore.

NORWAY SPRUCE *(Picea abies)*

Except at the extreme south, spruce is quite generally found thruout the forests of Sweden. At the north it has never attained the extreme limits where pine occurs, that tree at times, but usually birch, or pine and birch in mixture, constitute the timber-line growth. Only on the high Kiolen Mountains, toward the lower end of the peninsula, do we find spruce ascending higher than its two above mentioned competitors.

Dr. Nils Sylven has made a most careful botanical study of the common spruce of Europe with special reference to its types and variations in Sweden [67–20].

This tree probably surpasses pine in variability of most features, but especially in respect to vegetative ones; for example, at the north it readily reproduces by natural layering of lower branches, this being its predominant method under extreme adversity of climate. With all its variations, however, spruce does not fail from a forestal standpoint anything like so readily as Scotch pine when seed is transferred to a certain site from climatically different localities. It shows greater climatic adaptability than pine.

Dr. Sylven distinguishes the following vegetative forms of spruce:

(1) Pure Comb Type, where the main side branches show an even fringe of long drooping branchlets or twigs beneath them.

(2) The Irregular Comb Type has the same feature developed rather unevenly.

(3) The Band Type has its larger side branches clothed on either side with densely set short and nearly horizontal branchlets and twigs.

(4) The Plane Type is like the preceding, except that the side branchlets are longer and not quite so numerous.

(5) The Brush Type has its main laterals clad porcupine-like with a dense array of relatively short bristling branchlets.

Of the foregoing types, it is generally admitted that the first, or comb form, is thriftier in growth and more resistant to injury by fungi and adverse climatic conditions. Since little work has yet been done in breeding spruce, it is merely known that these forms do not breed true; hence some observers have referred their origin to the effects of soil and light conditions rather than heredity. The forms that follow are less common and tend to be freaks.

(6) The Snake Spruce shows very few and irregularly located branches which taper but little, as is also true of the main stem.

(7) The Weeping Spruce has long, drooping and usually unbranched branchlets.

(8) The Globe Spruce is the antithesis of the two preceding in having a very dense crown with many small branchlets so as to show the general effect of a huge witches' broom.

(9) The Table or Umbrella Spruce makes little or no height growth, but spreads so as to form dense and near-horizontal mats.

(10) The Pillar Spruce has a very dense but nearly columnar crown form.

Spruce has a typical flat root-system, but even this varies somewhat in keeping with site and stand conditions. On fertile soils, moist or poorly drained sites, and when growing in dense even-aged stands, the roots of spruce are very superficial or quite weakly developed. Because of the tendency on many spruce sites in Sweden toward excessive moisture, the rooting is very shallow and limited to a rather unstable soil stratum. This fact, combined with the heavy burden of snow the trees are often called to bear in winter, has from time to time resulted in destructive windfall and snow-break in various sections of Sweden.

The wood of spruce is neither strong nor durable. It is free from resin and not differentiated as to sap and heart-wood. These latter facts, together with its long, even fibres and light color, make it the ideal pulpwood. Prior to the development of the Swedish pulp and paper industry, spruce lumber was often not separated from pine in the sawmills, which tends to illustrate how different the wood of virgin Scotch pine is from that of most U. S. " hard pines;" since it is impossible for us to imagine, for instance, that our southern yellow pine could be used for most or all the same purposes as spruce. Wahlgren gives the below analysis for wood of Norway spruce in Sweden.

Cellulose	53%
Lignin	29%
Other Carbohydrates	13%
Resins, Oils, Fats, and Ash	4%
Albuminoids	1%

The wood weighs about twenty-eight pounds per cu. ft. under air-dry conditions (10% to 12% water content). Spruce wood is more hygroscopic than that of Scotch pine.

The bark is used to a certain extent in tanning in Sweden and Europe generally. Its tannic acid content varies from 5% to 18%, with an average of 8% for trees of saw-timber size. Trees of twenty-five to thirty-five years old are richest, but there is considerable variation with site conditions, being higher on the better.

At the northern part of its range, spruce shows the same narrow crown as an adaptation to the snowy climate which was noted for Scotch pine, and in addition the lateral branches droop to the extent of forty-five degrees at times.

Norway spruce is notably hardy in respect to winter cold, but young trees suffer often from late spring frosts thruout its range. It is also sensitive to high temperatures and drouth. Atmospheric moisture is necessary to thrift, especially in mature years, which raises a question whether this species is not today frequently planted for forestry purposes in certain sections of the U. S. A. where it is ill-adapted because of the continental character of the climate. Spruce bark is of quite uniform thickness and not adapted to resist the full power of the sun, especially where reflection from beneath exaggerates the heating effect. Under such conditions the cambium suffers and bark-burn occurs. This often gives rise to decay, as well as sets a period to rapid growth.

Spruce is more exacting as to soil than pine in respect to both moisture and fertility. It does not thrive on strongly acid soils. It requires more lime, potash and phosphorus than does pine. Its roots need aeration and the assistance of bacteri~~s~~a that cannot exist unless ample oxygen and a proper supply of organic matter are at hand.

The tolerance of spruce and its love of cool, moist soil enables it to compete quite advantageously with its two usual messmates,—pine and birch. In fact, it often tends to be a forest weed in Scandinavia because it comes in as advance growth under older stands of these light-demanders, and thus takes possession of sites where it is too exacting to thrive as they would.

Spruce seed is nearly the same size as that of Scotch pine from the same locality, but is an even red-brown in color, instead of being mottled or varying from white thru yellow and gray to black, as is common with pine. The cones contain 100 to 200 seeds, and vary in size with climate and individuality of the mother tree, so that a bushel may contain from 280 to 700. Table XXXV illustrates the variation of the seed in size and weight.

TABLE XXXV.—SEED OF NORWAY SPRUCE FROM DIFFERENT CLIMATIC REGIONS

Locality	Number of Seeds per Pound
Central Europe	54,000– 68,000
South Sweden	68,000– 91,000
Central Sweden	104,500–110,000
North Sweden	about 175,000

It has been asserted that spruce seed varies in germinability with the time of cone collection [74–508]. The below data supports this contention:

Seed from August collected cones—41–49% germination
Seed from September collected cones— 75% germination
Seed from October collected cones— 84% germination
Seed from November collected cones— 88% germination

Seed years are more frequent with spruce than Scotch pine. A full seed crop occurs in South Sweden at two to three year intervals on the better sites. In Middle Sweden the intervals average four years, and in Norrland still longer. Studies made in spruce stands near the Baltic Sea have demonstrated that a full seed crop in a thrifty stand of favorable age means the production of 110 to 120 pounds of seed per acre.

Norway spruce in Scandinavia has nearly all the fungous and insect enemies that afflict pine, and a number of others in addition. Its twigs and needles often suffer from needle lice (*Chermes strobilobius*) and *C. abietis,* which cause the formation of cone-like galls. Among the needle rusts may be named *Chrysomyxa abietis* and *C.*

ledi. The cone-scale rusts (*C. pyrolæ* and *Pucciniastrum padi*) often reduce the seed crop considerably. Spruce shedding-diseases (*Lophodermium abietis* and *macrosporum*) are sometimes injurious in the forest nurseries of South Sweden. The needle-miner (*Grapholita tedella*) is often associated with damage by the preceding fungi.

Ring rot and spruce rot (*Polyporus pinicola* and *P. abietis*) are frequent in stands of older trees.

Among insects probably the bark borer (*Ips typographus*) does most harm to middle-aged and older stands in Sweden.

Such thinnings as will keep stands in good growing condition are considered the most practical means toward protecting spruce against the enemies attacking its vegetative parts, altho there are certain root-rots that appear quite indifferent to the original thrift of their prospective host. It has been surmised that many spruce roots are broken due to the stresses developed when storm winds sway the heavy crowns of spruce, or if not broken outright the cortex is often ruptured, and such wounds doubtless give ready entrance to mycelia of underground-spreading fungi.

The spruce cone miner and seed-midge (*Laspeyresia strobilella* and *Perrisia strobi*) at times reduce the seed crop in quantity and quality.

In plantation spacing, it is usual in Sweden to choose a wider interval for spruce than pine where conditions are equally favorable to both trees. It is argued that unless pine is close spaced it tends to develop heavy lateral branches with consequent knots, but spruce has naturally a more aspiring habit and does not spread laterally as does pine. In silviculture with spruce in Scandinavia there has long been sharp contention. The " clear-cut and plant," or possibly seed, system long dominated the field of intensive forestry, but the younger generation of foresters look askance at the expense entailed and the dangers that beset pure even-aged stands. Stands more or less mixt and originated by N. S. R. become annually more nearly the universal ideal. Such ends are probably best attained by selection forestry, which may now be practically considered the national system of silviculture in Norway, or by group-cutting, slow shelter-wood, border-cutting, and small stand N. S. R. which are becoming popular in Sweden.

Careful selection management with some occasional soil cultivation seems best adapted to the silvics of this tree. This system, however, labors under a cloud in Sweden, because it is associated in the minds of older foresters and forest owners with the culling practice prevalent for a century in the over-mature and decadent stands of Norrland. The natural result of this cutting out of the best without regard to the future was deterioration. The first step toward a rationalization of cutting in these forests was " diameter limit " control. This gave results only a little better than uncontrolled cutting, but is still considered by conservative minds as typical of what may be expected under any selection cutting system. On the state forests that were once abused in this way, a three-cutting shelterwood method

TABLE XXXVI.—Norway Spruce in Central and North Sweden

(All data on per acre basis)

Age of Stand (yrs.)	Species	Stand after Thinning					Thinnings Removed						Total Yield			M.A.I. on Total Yield (cu. ft.)
		Trees per A.	S. A. (sq. ft.)	Average D.B.H. (in.)	Average Ht. (ft.)	Vol.	Trees per A.	S. A. (sq. ft.)	Average D.B.H. (in.)	Average Ht. (ft.)	Vol. (cu. ft.)	% of Stand	Vol. (cu. ft.)	Bark %	Thinning %	
Heavy Crown Thinning, Lilla Svältan Crown Forest, Central Sweden																
49	Spruce	677	140	6.2	55	4020	100	22	6.3	55	595	13	4615	10.3	13	94
54	Spruce	*518	131	6.8	59	3940	119	32	6.	57	940	20	5473	11.3	28	101
Heavy Thinning from Below, Ollestad Crown Forest, Central Sweden																
43	Spruce	1070	123	4.6	41	2723	1662	55	2.5	31	911	25	3634	15.1	25	84.4
43	Pine						18	3	5.5	40	55	100	55	24.5	100	1.3
43	Birch						10	1	3.7	32	12	100	12	25.9	100	.3
	Total	1070	123	4.6	41	2723	1690	59			977	26	3700		26	86.
47	Spruce	**670	103	5.3	45	2496	400	39	4.4	39	843	25	4251	12.7	41	90.4
Crown Thinning on a Drained Bog, Hemsön, North Sweden																
64	Spruce	656	150	6.5	53	3931	219	44	6.1	50	1051		4982	12.4		78
64	Pine	15	7	9.4	58	196	63	58	6.5	50	323		518	13.2		8
	Total	671	157			4127	282	102			1374		5500			86
Heavy Crown Thinning Valaskogen, Hoting, Northern Sweden																
130	Spruce	595	97	5.5	55	2705	266	32	4.7	52	851	24	3555	16.3		27.4
130	Pine						11	3	7.5	53	89	100	89	16.3		.7
130	Birch						157	52	7.8	57	1383	100	1383	18.8		10.6
	Total	595	97	5.5	55	2705	434	87			2323	46	5027			38.7

*The C. A. I. for 5 yrs. covered by the above table = 172 cu. ft. or 3.86 %.

**The last thinning in both above tables was somewhat complicated and made heavier than the ideal by reason of snow damage. The C. A. I. for 4 years covered by the above table = 155 cu. ft. per acre or 5.1 %

has been adapted and usually attains very satisfactory reproduction, since it permits the variation in treatment that each area seems to require.

Spruce in Sweden naturally varies in its ability to lay on increment when stands are compared in the north and south of that long-stretched land. Table XXXI gives an idea of what can be expected of this tree in the south. The growth of stands in Central and North Sweden is shown in Table XXXVI.

Mixt stands of pine and spruce are naturally common in Sweden, and are being more and more looked upon with favor by forest managers. It is even now considered highly desirable that some birch be intermingled with conifers wherever the exigencies of market and transportation permit. The two important conifers of Northwest Europe are in many respects natural complements, as is seen most obviously in their rooting and by light demands. In varying proportions mixt pine and spruce do well on all but the poorest sites and constitute incomparably the most important forest type of the Baltic lands. In these mixtures pine dominates on the poorer dry sites, while it is reduced to secondary standing in valleys and on cool, moist and fertile slopes; especially if regeneration has been secured without the aid of fire.

These two trees in mixture not only make fuller use of the production factors of a site, than one could do alone, as all foresters know from their rooting and tolerance, but they are highly advantageous from a protective standpoint. Pine enables a stand to resist storms, while the intermixt spruce excludes forest weeds and brings about a very desirable still-air condition under the crown canopy; thus retaining moisture and carbon dioxide gas for constructive use by the trees. Insects and parasites in general do far less damage in these mixt stands than where one species grows alone. The mixt stands, under intensive management, are very desirable from a purely business standpoint, since cutting can be ordered in such wise as to supply those market demands that are strongest at the time.

The reproduction of mixt stands is universally best attained by natural methods. Group selection cutting and the cleared methods have given good results in Sweden. There is nearly always a considerable scattering of advance-growth spruce under older mixt stands. This reproduction was long thought worthless or undesirable by many foresters, but studies by the State Forest Experiment Station have demonstrated its ability to recover from suppression and grow along thriftily with the pine that comes in after clearing. The border-cutting of Wagner has given good results locally.

Some efforts have been made in Sweden to establish mixt coniferous stands artificially,—both by seeding and planting. The species concerned are fairly well adapted to success in theory, but the attainment has rarely equalled the hopes entertained. As a rule, the pine so rapidly forges ahead of spruce that unless some cutting is done to favor the latter, it never attains a place in the crown canopy; especially under the predominant Swedish practice of mixing seed of the two trees and sowing this together intimately in the same prepared spots or rows. Yet even some apparent failures from this method, judged in early years of the resultant stand, have later shown quite satisfactory mixtures when thinning removed some of the pine and spruce entered its rather delayed period of rapid height growth.

The yield data in Table XVII from Malingsbo gives an idea of yields actually possible from mixt pine and spruce in Central Sweden on average sites. The heaviest stands in the country are of this type. Table XXXVII shows, for comparison with pure stands, what mixt ones yield in South and North Sweden.

MISCELLANEOUS AND EXOTIC CONIFERS IN SWEDEN

The Common Juniper *(Juniperus communis)*,—" En "

This circumboreal species attains small tree size almost thruout Sweden, which is true in only limited localities of its far-flung range. It grows very slowly at best, but is useful as fencing material and in many domestic articles where its durability recommends it. Being quite intolerant of shade, it is restricted, as a rule, to waste areas and rocky openings in the forest where other larger and more rapid growing species do not crowd it so hard. Grazed lands usually show this juniper, because it is the most nearly immune conifer of the Old World in respect to grazing injury.

The presence of this tree or bush usually indicates a favorable lime content in the soil and that the site would support a stand of spruce if grazing ceased and nature were allowed to work out her usual forest succession.

Specimens of this juniper are recorded in Sweden with a height of forty-five feet or more, and age of 1,000 years.

The Yew *(Taxus baccata)*,—" Idgran "

In Sweden the yew is rare and seldom or never develops to tree size. Its natural range is limited to the south coastlands from Gothenburg around to Gefle. It is apparently tending toward extinction, and has few friends, because all its parts except the fleshy berries are reputed poisonous. Growth is very slow. Wood is heavy, hard and durable. It sometimes attains an age of 2,000 years or more [40–82].

The Larches (*Larix, sp.*),—" Lärkar "

This genus of trees is not represented naturally in Scandinavia or Finland, but it includes the most important exotic species yet introduced. The European species (*L. decidua*) is most commonly met and is locally naturalized. Most of the following discussion refers to this tree. Siberian larch (*L. sibirica*) is preferred, however, by foresters, because of its straighter bole form.

Japanese larch (*L. leptolepis*) has been planted in limited numbers during the past two decades, but it shows a marked tendency to crookedness for some reason. It is not noticeably more resistant to larch canker (*Dasyschyfa willkomii*) than are the Siberian and European species.

TABLE XXXVII.—MIXT CONIFEROUS FOREST STANDS
(All data on per acre basis)

Age of Stand (yrs.)	Species	Stand after Thinning					Thinnings Removed					Total Yields			M.A.I. on Total Yield (cu. ft.)
		Trees per A.	S. A. per A.	Average D.B.H. (in.)	Average Ht. (ft.)	Vol.	Trees per A.	S. A. (sq. ft.)	Average D.B.H. (in.)	Average Ht. (ft.)	Vol. (cu. ft.)	Vol. (cu. ft.)	Bark %	Thinning %	
Jönoker County Forest, South Sweden, under Heavy Rational Thinning															
Thinnings Removed Earlier								51	8.1	69	522				
108	Pine	130	127	13.4	86	4679	78	47	10.5	80	1563	6765	14.2	31	63
108	Spruce	232	56	6.7	67	1879	53	18	7.8	69	590	2469	13.1	24	23
	Total	362	183			6558	182	83			2675	9234	13.9	30	86
Anundsjö Church Forest, check area (only dead trees removed)—North Sweden															
91	Pine	362	130	8.1	60	3629	40	3	3.5	38	56	3685	14.2	1.5	40
91	Spruce	1442	74	3.1	41	1683	28	1	2.8	30	20	1703	15.8	1.2	19
91	Birch	93	6	3.4	40	122	20	1	2.5	28	10	133	13.7	7.9	1
	Total	1897	210			5434	88	5			86	5521			60
*Omberg Crown Forest, South Central Sweden—Heavy Rational Thinning. Planted European Larch and Natural Norway Spruce															
69	Larch	131	118	12.8	98	5629	36	26	11.6	95	1216	6845	18.6	17.8	99
46	Spruce	618	62	4.3	39	1379	142	12	4.0	37	366	1643		16.2	36
	Total	749	180			7008	178	38			1482	8488		17.5	135
73	Larch	84	87	13.7	100	4203	47	38	12.2	97	1751	7168	17.6	41.4	99
50	Spruce	484	62	4.8	44	1530	134	9	3.5	37	189	1985		22.9	40
	Total	568	149			5733	181	47			1940	9153		37.4	139

*Optimum site and stand of larch in Sweden, according to some authorities.

The C. A. I. of this stand during the 4 years elapsing between inventories above recorded was 166 cu. ft. per acre per year ~~of~~ or 2.26 %.

The West American larch (*L. occidentalis*) has been experimentally planted at Bjurfors and a few other localities, but it suffers occasionally from spring frosts and shows little promise.

Larch, in Sweden, shows considerable variation, in keeping with soil and silvicultural conditions. The genus in general demands a fresh, loamy soil of fair fertility. Where the tree has been planted on inferior sites it not only makes slow growth, but also shows greater injury from its fungus and insect enemies. None of the larches yet tried do very much in North Sweden, altho there these trees seem to be practically immune to their most serious drawback, the canker. Failure toward the north is probably attributable directly and indirectly to the rooting habit of the genus. Larch seedlings show rather strong tap-root development, but dependent upon soil factors, this type of rooting is sooner or later lost and long lateral roots are developed. Just as soon as the tap-root becomes atrophied or unimportant to the tree in a relative sense, just that quickly its optimum vigor and thrift passes. Some of the factors that favor the formation of lateral roots at the expense of the central deep-going main axis are (1) low soil temperature, (2) high water-table, especially during the early part of the growing season, (3) hard-pan, (4) concentration of fertility in the superficial soil. Every one of the above conditions is very common, and the first is almost universal in Central and North Sweden.

In respect to crookedness of growth and resistance to disease, Swedish planters of larch have drawn very emphatic conclusions, proving that the seed origin is a highly important matter as to European larch. Apparently this species has developed several varieties or strains in the widely scattered localities of its native and naturalized range. These varieties differ importantly from the standpoint of forest management and protection. Larch trees from seed of Scotch or Silesian (Polish) origin are vigorous and straight-growing. Siberian larch shows about the same characteristics, but does not grow as rapidly as the European species in early life.

A number of rules for the cultivation of the larch in Sweden have been deduced from experience. Some of the most generally accepted of these are summarized herewith:

(1) A certain calcium content is required in the soil for satisfactory growth.

(2) In localities near the seacoast and in moist valleys with poor air circulation the canker disease is deadly to larch, particularly toward the south. (A continental climate seems to favor this genus.)

(3) In Central and North Sweden the canker disease is saprophytic almost exclusively and may not occur at all.

(4) Heavy thinning from below helps to minimize damage by canker, since it permits better air drainage. All wood and brush, so far as possible, should be promptly removed from thinned stands, as it may nurse the disease in saprophytic form so that parasitic trouble will later develop therefrom.

(5) Mixtures of larch and spruce are considered inadvisable from

standpoint of canker disease. This trouble has been found to gain its first foothold on trees in most cases through the wounds made by the spruce needle-louse (*Chermes abietis*). This insect attacks larch, but cannot survive certain stages in its life history unless it has spruce as its host.

(6) Larch is most resistant respecting all its enemies when every tree in a stand is growing vigorously. To get this condition, heavy and frequent thinnings are necessary.

(7) Prof. Schotte [54–657] strongly advises mixture of larch and Scotch pine on all better soils. The larch should make up 20% or less of the stand by number of boles in order that canker may be avoided on pine sites. Such mixtures will improve the site and increase yields.

Many of the above rules have little present interest to silviculture in America, since we have been so fortunate as to lack the canker disease, but we have an almost equally serious pest in the sawfly (*Nematus erichsonii*) which periodically develops in such numbers as to be a calamitous plague, responsible in times past for the destruction of many thousand acres of promising East American larch (*L. laricina*). This insect meets the European and Siberian species with a hungry welcome, as they are probably its original hosts in its Old World home, as it is doubtful if this sawfly was indigenous to America. It is recorded [74–542] as occasionally and locally denuding trees of their foliage in Sweden, yet it is not classed as a really serious threat to the success of the species, except under conditions where the insect is introduced to new fields to which its parasites have not yet penetrated. If this assumption [54–671] is correct, we in America need only go to Europe and identify the organisms that hold the pest in check, introduce them into our northern forests, and one of our best trees will be redeemed from the heavy shadow that hangs over it.

Larch, in Sweden, is attacked by a smaller sawfly (*Nematus laricis*), which has a brown head to distinguish it from the preceding with its typical black head.

Among other insects limited to the larches that are occasionally injurious in Sweden may be mentioned the larch tree moth (*Coleophora laricella*) and the larch spinner (*Steganoptycha diniana*).

Several insects, especially needle lice and related forms, occur on larch in common with other conifers, as is likewise true of certain fungous species.

Larch rarely reproduces itself naturally in Sweden. Its strong demand for sunlight can seldom be satisfied, and the early seedling stage is too tender to successfully resist the many dangers that threaten them. Planting or mixing the seed with that of other conifers and sowing in prepared spots or rows have been the dominant methods of stand establishment. Originally larch was recommended for planting on the poorest, sterile sites and on marshy areas, particularly after these had been more or less thoroly drained. Numerous disappointed hopes have changed the opinion of foresters as to what sites the larches should occupy, so that the rules heretofore set forth give a good idea of present practices in Sweden.

Wahlgren advises growing larch in large pure groups or small stands scattered here and there thru areas of other coniferous forest, on the sites that are well adapted to the needs of the genus.

It is common to find Swedish foresters using European and Siberian larch seedlings and transplants to re-enforce natural growth and fill in fail-spots in plantations of other species. This practice is based on the rapid early growth made by larch, and may not at all give the tree such site conditions as it requires for thrifty development.

Because of the few native species in the forests of Sweden, it has long been considered desirable to introduce exotics from regions of similar climate; the genus *Larix* being looked upon with strong hopes, due to its notable preference for cold and humid condition. None of the species of Scandinavia yield wood of marked durability in contact with the soil, so in this respect the wood of larch is held in high esteem. After more than fifty years of experimental and half-commercial planting of European larch, it is still a moot question among foresters as to the practical utility it may serve in Swedish forestry.

EUROPEAN SILVER FIR *(Abies pectinata)*,—"ADELGRAN" OR "SILVERGRAN"

This, next to certain larches, is at present the most important exotic tree in Swedish forestry. Stands up to fifty or sixty years of age are to be found in several localities of South and South Central Sweden. Those at Omberg, Visingsö and near the south coast of Sweden are most notable. In Denmark some splendid stands are to be seen.

In numerous places this species has begun to seed in naturally in the vicinity of older stands, and on deeper soils of good quality where the climate is not too severe success and satisfaction seem assured. When one visits the Swedish stands of silver fir he is immediately impressed by the straight boles with a minimum of taper and the extremely dense crown canopy. The tree grows apparently as well or better than in many localities of its native range.

Where the site offers favorable conditions for the development of the tap-root silver fir surpasses spruce in thrift and resistance to fungi, wind, and other dangers. It is somewhat sensitive to drouth and frost under practically all conditions, and must be protected in early life until good stand density is attained. It is hardy enough for use in forestry up to the 65th parallel of latitude. In Sweden it is usually planted under mature or older stands of oak, birch or other species. Sometimes it is planted in small pure stands on sites well protected by the surrounding topography or tree growth. Dry, sandy soils, as well as strongly acid ones, are not adapted to this tree.

German studies show that while Norway spruce transpires 206 pounds of water for each pound dry weight of growth it makes annually, silver fir transpires only 77½ pounds [74–557], which strongly demonstrates the superior efficiency of the fir in the use of water. But it was proven further that silver fir trees have such dense crowns that only 43% of the annual precipitation ever reaches the ground beneath them. (With twenty-eight inches precipitation per year, only twelve reached the earth.)

Some years ago, in South Sweden, silver fir stands were established by seed-sowing, but this is considered too expensive and has given away to use of nursery grown (1–2) or (2–2) transplants. It is considered best to sow seed in fall, as drying over winter decreases germinative energy. The resin or turpentine stored in the vesicle of each seed protects autumn sown seed against birds and rodents.

TABLE XXXVIII.—Growth and Yield of Silver Fir, Island of Bornholm, Denmark

(After Prof. C. Metzger)

Age	Trees per Acre	Average D.B.H. (in.)	Average Height (ft.)	Volume Data		Total Yield
				Stand After Thinning (cu. ft.)	Thinnings Removed since Preceding Date of Estimate (cu. ft.)	
15	2038		6.2	114		114
20	1698	2.2	12.8	586	57	643
25	1415	4.0	20.7	1743	172	1972
30	1180	5.5	29.5	3215	329	3772
35	983	6.6	38.0	4716	472	5746
40	820	7.6	46.2	6102	615	7747
45	683	8.5	54.1	7317	729	9691
50	569	9.2	61.3	8217	829	11420
55	475	9.9	68.2	8746	871	12820
60	395	10.6	74.5	8846	886	13779
65	330	11.4	80.4	8946	900	*14779

*M.A.I. = 227 cu. ft. From 60 to 65 yrs., the C.A.I. = 200 cu. ft. Prof. Metzgar estimates that at 80 yrs. this stand should have yielded 7,717 cu. ft. of wood and the final crop should be 10,718 cu. ft. or a total of 18,435 cu. ft., giving a M.A.I. of 230 cu. ft. per acre for the entire life of the stand.

In Denmark, direct seeding is still used in order to get stands of high density. Seed is sown in prepared belts or narrow strips at the rate of about twenty-eight pounds per acre, which is a rather heavy primary investment. Sowing much less seed in prepared and closely spaced spots has been found satisfactory in Sweden, where a protecting overstory is present.

Because of its superior ability to resist the two deadly root-rot fungi that afflict Norway spruce, silver fir is especially recommended for planting up the holes that must often be cut in spruce stands when they are attacked by *Armillaria mellea* or *Polyporus radiciperda.* In fact, it might well replace spruce on sites where these troubles are to be feared.

Frequent light thinnings seem most favorable to development of fir stands. Due to the ability of the species to form stands with numerous canopy levels, thinning can be safely delayed much longer than for spruce. Table XXXVIII gives the yield of a stand on the Danish island of Bornholm, near the south coast of Sweden.

OTHER FIRS *(Abies, sp.)*,—" ADELGRANAR " EXOTIC IN SWEDEN

To a limited extent Siberian silver fir (*A. sibirica*) and Canadian balsam fir (*A. balsamea*) are found planted for forestry experimental purposes. Both thrive in early life and are climatically well adapted to Scandinavia, but it is doubtful whether either can approach in volume yield the performance of European silver fir on favorable sites over a relatively long rotation. Both these species are native to regions of continental climate in general and may possibly be considerably stimulated in rate of growth under the more humid conditions prevalent in Scandinavia and Finland. Balsam seems to show this stimulus. In south and Southwest Sweden are specimens and small stands, up to forty and sixty years old, that are very satisfactory and reproduce themselves effectively by N. S. R.

Siberian silver fir has a very boreal range, and in Central Sweden has been killed in some instances by late spring frosts.

American silver fir (*A. concolor*) and Nordmanns fir (*A. nordmanniana*) are beautiful ornamentals in Central and South Sweden. They have never received much attention from a forestry standpoint except in Denmark, where some planting of the latter has occurred. Its crown is so dense that it is unlikely to succeed except where a good supply of subsoil moisture is at hand.

WHITE SPRUCE *(Picea canadensis)*,—" VITGRAN "

This tree has achieved a real reputation in Scandinavia, due to its ability to withstand wind and cold. It also surpasses Norway spruce in resistance to the root-rot fungi so destructive to that species, and in ability to grow on coast sand-dunes as well as sterile, dry and acid sites. In Denmark, especially in the northwestern part of the kingdom, it is the commonest and most useful tree in many localities. As a rule, it forms the outside protective mantle about every spruce plantation and is frequently alone or mixt with mountain pine (*Pinus montana*) as a hedge or shelter-belt along farm boundaries and field borders. We who know the tree in America will not be surprised that it grows relatively slowly, attains but small size and shows poor form with persistent limbs on the sites where it has been mostly planted. The wonder is that it does so well, or even lives at all. It is propagated and managed in the same way as the common spruce. It seeds abundantly and at an early age. A pound of Scandinavian seed contains 135,000 to 200,000 grains.

OTHER SPRUCES *(Picea, sp.)*,—" GRANARTER " EXOTIC IN SWEDEN

In South Sweden and Denmark, Sitka spruce (*P. sitchensis*) shows great promise. It surpasses the common spruce in rate of growth, especially on poor or wet soils, and in resistance to winds from the sea. Its sharp needles protect it against damage by animals. It is rather sensitive to winter cold, and after a dry, cold winter may shed many or all its needles.

As ornamentals, and occasionally in experimental forestry, one meets Colorado blue spruce (*P. pungens*) and Engelmann spruce (*P. engelmennii*). Both thrive and look well, but grow slowly. The latter tree should be worthy of trial planting in timber-line localities [74–571]. In Prussia the latter has been successful on poorly drained sites where Norway spruce could not possibly succeed.

DOUGLAS FIR *(Pseudotsuga taxifolia)*,—" DOUGLASGRAN "

In spite of the great reputation this species has won in Germany, Denmark and the British Isles, it has been very little considered as a tree for forestry in Sweden. This is due primarily to the difficulty of getting suitable seed. The rapid growing green form of the tree is subject to frost damage to a serious extent, and the blue form is too slow in growth to be really desirable. Careful studies in American forests should succeed in locating regions, in British Columbia for example, from which seed would be well adapted to the Swedish climate [59–5/1929–260].

EUROPEAN MOUNTAIN PINE *(Pinus montana)*,—" BERGTALL "

This pine has earned a well deserved meed of praise on the sand fields of South Sweden and Denmark, as well as on adverse sites in southwest Norway. Its chief virtues are (1) adaptability to all kinds of adverse soils, and (2) ability to withstand extreme atmospheric inhospitality. It is primarily used as a pioneer crop on sites where it is hoped that a more exacting and better revenue-yielding tree may later be introduced, or to hold sand-dunes against the force of the wind.

It is a seeming paradox that this tree of the high summits in south and south-central Europe should be most successful in combatting the salt breezes and sand-laden blasts of the Baltic and North Seas under tide-water conditions, yet it has surpassed all of the numerous species tried to date. The heavy canopy with which it clothes a site in early life is notable, and due probably to its being plastic in its light requirements as well as soil needs. Only in the immediate neighborhood of the ocean are the ill effects of salt vapors noticeable on the crowns and needle tips. Elsewhere it usually forms a very dense growth that excludes all undergrowth and heath shrubs from the forest floor.

Dendrologists usually recognize four varieties of mountain pine. Two of these forms, *P. montana mughus* and *Pumilio,* are dwarfish or shrubby and practically world-wide in distribution, as border and rock garden ornamentals. The species met in Scandinavia is usually *P. montana uncinata,* colloquially termed the " many-boled " pine. It grows nearly upright, or as well as can be expected in connection with its clumpy habit, but at a slow rate, and comes to early maturity. Small poles, posts and fuel wood are the only products one sees taken from the stands of this tree, as a rule. In fact, on considerable areas, where it is planted in mixture with Norway spruce, it is cut down and spread over the soil for protection and fertility, without any attempt to derive merchantable products from the bowed and densely branch-clad stems.

A much better tree in every respect, except possibly hardiness, is the *P. montana* var. *gallica,* one-stem mountain pine or Pyrenean mountain pine. It is a really worth-while wood producer. Growth-rate is good, considering the sites it occupies. Sometimes wind and snow damage older trees on the stoneless soils it occupies. Relatively few stands of this tree are seen in Sweden and Denmark, but they cannot fail to impress the observer by the heavy shade they cast and great number of straight boles per acre [74–574].

One rarely sees mountain pine above forty feet tall and eight inches in D. B. H., but P. E. Müller, in Denmark, has constructed Table XXXIX, showing what the tree can do on the more favorable sandy sites.

TABLE XXXIX.—HEIGHT GROWTH OF MOUNTAIN PINE ON BEST QUALITY DANISH SAND-DUNES

Age (yrs.)	Height (ft.)
20	20.6
40	36.1
50	41.2
70	51.5
90	56.7

Wahlgren [74–697] advocates mixing mountain pine seed with that of Scotch pine when it is to be used in direct seeding on sterile soils. The mountain pine does not hinder the other in any way, but aids it in quickly covering and protecting the site.

Mountain pine is not a heavy producer of wood fibre on the basis of volume. The results from Danish plantations have been given by E. Dalgas and P. E. Müller as follows; on the acre basis:

Age of Stand (yrs.)	*Final Volume (cu. ft.)*	*Volume of Thinnings during Rotation (cu. ft.)*	*Total Yield (cu. ft.)*	*Mean Annual Increment (cu. ft.)*
50	1572	*1715	3287	66
60	3287	*1172	4459	74

* This data is respectively from heavy and light thinning practice. It would seem that the latter is more profitable; as would be logically assumed, since protection of the soil is a *sine qua non* of all cropping on these sites.

Wood of the species as grown in Scandinavia is considerably heavier than given by German authorities for that produced in the homeland of the tree. In fact, here it is only surpassed by the yew among European conifers. Its density, resin content, high fuel value, and durability are explained by an air-dry specific weight of 83% (variable from 72% to 94%), corresponding to 52 pounds weight per cu. ft. (varying from 45 to 59 pounds).

OTHER PINES *(Pinus sp.)*,—"TALLARTER" EXOTIC IN SWEDEN

Austrian pine (*P. austriaca*) has been planted to a limited extent for forestry purposes and is a fairly frequent ornamental. It has failed uniformly in forest planting, due to fungi and snow damage. This fact is possibly due to its being commonly set on sand dunes or sterile areas with strongly acid soil. Prof. Wahlgren [74–581] advises its use on shallow, dry limestone soils such as are common to the island of Gottland in the Baltic Sea.

The American white pine (*Pinus strobus*) has no standing in Swedish forestry. The humid climate predisposes it to the most serious ravages of the blister rust (*Peridernium strobi*), as was notably exemplified on the Danish island of Bornholm, off the south coast of Sweden, where considerable forest stands were completely devastated by this deadly fungus [38–12].

American pitch pine (*P. rigida*) has been experimentally planted and shows a fair degree of thrift, but it is only hardy at the south and suffers seriously from snow at times.

Banks or jack pine (*P. banksiana*) has been rather uniformly a failure in Sweden, contrary to what one would logically suppose. It grows crooked, suffers from snow and has at times died in large numbers from some undetermined cause.

Lodgepole pine (*P. murrayana,* and the coast form *contorta*) has thriven and is a tree of real promise for adverse and timber-line localities in Sweden and Norway. A sand dune planting, seen near Esberg, Denmark, was eight years old and growing rapidly in 1925, but it had been almost completely defoliated by a sawfly (*Lophyrus* sp.).

Swiss stone pine (*P. cembra*) and its Siberian variation have always been looked upon with interest by foresters and economists in Sweden. As long ago as 1660, when a crop failure brought famine to North Sweden, it was proposed that this tree be planted as a source of food in times of need, because of its large seeds it was given the name "bread-pine," and periodically, down to the present, has been sown and planted in an experimental way, yet without any result worthy of mention. Its very slow growth is the obstacle to success, permitting native growth to crowd it out on most sites. Extreme hardiness commends it for experimental work with lodgepole pine and American alpine larch on timber-line sites where the forest has been tending to retreat for centuries.

The nuts yielded by the tree are very tasty, but smaller than those of American pinyon, from which it differs emphatically in being a species of the *cold* instead of *dry* timber line.

SWEDISH HARDWOODS

BIRCHES *(Betula, sp.)*,—"BJÖRK"

There are apparently two tree species of birch in Scandinavia. *Betula alba,* Roth (*B. pubescens,* Erh.) is the "Glasbjörk" of Sweden characterized in its type form by tomentose-felty twigs and a more upright branch habit. *B. pendula,* Roth (*B. verrucosa,* Erh.) is the " Masurbjork " with warty to smooth twigs and often developing long, drooping lateral branchlets. The seeds and cone scales of the two species differ also. But separation of the two trees is not so simple as concerns many individual trees, since many hybrids, intermediate forms and variations occur [74–679].

The last named species does not go so far north or so high on the mountains as its associates. In South and Central Sweden both are very intimately intermingled. In the timber line forests botanists have distinguished *B. tortuosa,* which is quite truly descriptive of the form birch exhibits in such habitats; yet other careful students name this tree variety *subalpina* of *B. pubescens* (or *B. alba*). Except for this very marked climatic type, the rest of the trees in the genus, in spite of numerous minor variations, are very similar in every silvical and forestal feature. In fact, this is true of the boreal or alpine form if its stunted or crooked habit and ability to reproduce efficiently by vegetative means are left out of the equation.

Altho commercially far less important than pine or spruce in Sweden, yet it ranks next to these trees in that respect and is probably nearer to the hearts of the people in the Baltic lands. It might almost be called the national tree of Sweden, it is so close to the affections of old and young thruout the length and breadth of that country. Both winter and summer it is a cheerful tree without the somber air of the dark evergreens. By its change with the seasons it appears to shape its habit to the prevalent moods of man. In spring joyous expectations quiver in the vernation of each tender leaf. In summer the beauty and efficiency of rapid growth and accomplishment sit enthroned in its full dense crown. In autumn there is a brief and glorious celebration of color to return thanks for the year, then the watery sap changes to oils and sugars while the tree stands clean and brave to face the storms of winter. During that austere season its moods change with every phase of the weather; laughing and sparkling in sunlight always, but magnificent in its garments of diamonds when rime-frost comes. Under gray storm clouds it stands a portentous specter warning man and beast to seek the fireside or other shelter where creature comforts abound. No mental picture of Sweden is complete without its groups or grove of birch trees near the house where a table is spread in the shade during the long and ideal summer days. Around this sylvan banquet board the sturdy members of the family gather at least five times daily, partaking of coffee, cakes of wondrous taste and variety with the more substantial viands characteristic of the land.

The fuel of Sweden is generally birch wood. Even in Stockholm the wood industry is very important. Boats and rail transportation are necessary to move this wood, since it cannot be driven on streams with practical satisfaction. This fact tended to make birch a weed in the esteem of foresters for less accessible localities for many years, until quite recently they came to a realization of its biotic relations and the rôle it plays in the economy of forest soils.

Birch will grow on practically all sites, but develops its best pure stands on soils holding a fair modicum of clay and with good moisture content. In poorer soils it is shorter lived and attains but small size. The " Masurbjork " (*B. verrucosa*), silver birch of some English writers, is more modest than its sister tree and really thrives on dry ridges and on soils of pure peat. Birches make their greatest gains in the forests of Scandinavia when fire or ill-guided cutting wrecks coniferous stands. The seeds germinate in vast numbers, and if not killed by dry weather at a very early stage in life, seedlings are persistent wherever abundant light is available.

Dry weather is always detrimental to these birches because of their superficial root-habit. Ice and wind overturn trees at times, but do more damage by breaking off large limbs and permitting wood-rotting fungi to attack the non-resistant wood.

TABLE XL.—YIELD TABLE FOR BIRCH IN SWEDEN
(Data on per acre basis)

Age of Stand (yrs.)	M.A.I. (cu. ft.)	Average Height (ft.)	Average D.B.H. (ins.)	Sectional Area (sq. ft.)	Volume Yield (cu. ft.)
Site Quality I—(Good and Very Good)					
30	29	39	4.6	46	857
40	34	52	5.8	56	1358
50	34	60	6.6	65	1715
60	33	67	8.2	73	1958
70	31	72	9.4	79	2144
80	29	75	10.6	82	2286
Site Quality II—(Medium to Poor)					
30	20	34	3.5	37	614
40	26	44	4.9	54	1029
50	26	51	6.1	57	1315
60	26	56	7.4	64	1572
70	25	59	8.6	70	1758
80	23	61	9.8	73	1815

Note:—Thinnings not considered; values probably low. Compare with U. S. D. Ag. Bulletin on Paper Birch in New England, Forest Service Circular 163, by S. T. Dana.

Among the serious decay-causing organisms that flourish in birch heartwood may be listed *Polyporus betulinus, P. ignarius, P. fomentarius, P. nigricans* and *Armillaria mellea.* Old birch stumps are considered a nursery for the latter fungus from which it spreads to coniferous hosts. *Diaporthe aristata* is a canker disease on birch in North Sweden that does considerable injury.

The growth of Swedish birch stands has not been much studied to date. Table XL, converted from a report of the Forest Research Station by Prof. Schotte, gives an idea of yields from birch in Central and South Sweden or Finland. On basis of height-growth made by dominant trees, sites occupied by birch were separated into two classes.

The low volume yield and sectional area values at D. B. H. are characteristic of birches in general, and other intolerant trees as well. These data demonstrate the inadvisability of growing such trees in pure stands, unless it be for a single generation as a preparatory or pioneer crop. The excellent height growth made by birch is notable everywhere except on sites exposed to constant strong winds.

It is in mixture with other and more tolerant species, especially conifers, that the birches are capable of their greatest service to forestry. This service may not be entirely or even at all in the nature of wood yield. It will rather exist in the favorable influence exerted by the tree upon the biology and physico-chemical conditions of the soil. It has even been asserted that leaf-fall and débris from birches improve the drainage of a soil [74–693]. Be this as it may, we cannot doubt that the large quantity of easily decomposed litter deposited annually by birches has a marked effect upon nitrification and development of crumb-structure in soils. These favorable changes from the effects of birch litter may be easily accounted for by the high lime and magnesium content the analysis of this litter shows; as the influence of these minerals in the soil and on the metabolism of all plants is well known. It was long supposed that beech litter was unequalled in its favorable bearing upon the soil, but recent research proves that of birch to be as good and that of the forest elm (*Ulmus montana*) and a few other species to be better [19–252]. Table XLI gives analyses of birch and pine foliage so far as the content of essential mineral ash compounds are concerned [74–693]. It illustrates well the efficiency of these trees as to ability to concentrate and retain soil fertility in the superficial soil strata. The leaf-fall from a birch tree annually is doubtless considerably higher in quantity than from a pine of the same D. B. H., since the one sheds all its leaf canopy every fall while the other drops but 30% to 45%, which merits the assumption that the roots of birch must be very effective absorbers of fertility thruout the growing season, else they could not supply the quantity required for vigorous development of the tree in all its parts. From present information, we may venture to believe that the birches are the great cultivators, improvers and upbuilders of northern forest productivity; especially worthy of being fostered in those extreme localities as to climate, where beech and other hardwoods do not grow.

TABLE XLI.—ANALYSIS OF PINE AND BIRCH FOLIAGE IN SWEDEN AS TO ESSENTIAL MINERALS (AFTER TIBERG)

Mineral Compound	Pine Needles	Birch Leaves
Lime	0.400 %	1.340 %
Magnesia	0.050 %	0.360 %
Potash	0.134 %	0.255 %
Phosphoric Acid	0.104 %	0.250 %
Nitrogen	0.469 %	0.959 %

The light shade cast by birch and aspen is often used by the practicing forester in Sweden as a nurse shelter for the more productive conifers, especially spruce on recently drained marshlands. These reclaimed areas tend to show naturally a cover of birch very early after removal of excess water. Seeding with pine and spruce gives ideal stands on such sites in many instances. Even pine can struggle up through birch stands on poorer soils where the canopy is not so dense. Some of the best stands of these types as to origin may be seen on the Bjurfors Crown Forest [32–195].

OAK *(Quercus pedunculata* and *Q. sessiliflora),*—"EK"

Both the stalked and sessile white oaks of Europe occur native in Sweden, but the latter species reaches its northern limit of range at the 54th parallel of latitude and does not go so high above tide. In practical forest management no distinction is usually made between the two trees, as their silvics and products are almost identical.

In former times, extensive essentially pure stands of oak were characteristic of the whole south of Sweden, up to the valley of Lake Malar and its tributaries. The tree was most important, however, on the better drained soils in coastal localities. The good soils occupied by oak naturally led to its elimination by advancing agriculture. Even during Viking times in Scandinavia the wood of oak was highly considered in connection with shipbuilding, as was likewise true in later days when the Hanseatic League dominated the Baltic world and gave oak lumber a considerable commercial value for other uses as well. Oak grows slowly at best and especially suffered in its struggle for existence near the seacoast towns and cities of Scandinavia. Grazing was always important to the livelihood of man in such localities and was favored (at least temporarily) by annual or frequent burning of the areas where oak forests might have been otherwise re-established. The practically barren heath areas in South Sweden and Northwest Denmark originated in a great measure on sites where once stood oak woods. Repeated fires and a naturally severe climate finally drove even grass from the soil, and at the time the black death swept Europe considerable areas of these poor lands were depopulated, not to be again occupied until the close of the nineteenth century.

To a certain extent oak has been artificially re-established in South Sweden. The most notable instances of this sort will be met on crown lands on the island of Visingsö in Lake Vettern, where plantings of excellent thrift, dating back as far as 1830, may be seen. Nearly all such stands are the result of direct seeding, usually in cultivated rows at a very high expense per acre for acorns. The reason for demanding such high density in young stands of European white oak lies in its prevalent youthful habit. Even up to a small pole size it is almost impossible to find anything approaching straight growth in oak woods of the Old World. Only by close crowding can any trees even approximately straight be grown. This fact shows a notable contrast in favor of American oaks, such as red (*Q. rubra*) and white (*Q. alba*), where crookedness is the exception instead of the rule.

The oaks of West Europe are quite sensitive to wind injury. On exposed ridges in West Denmark one often sees low matted or flat-conical clumps of stunted growth with a maximum height not in excess of ten feet, but frequently showing an age of two hundred to four hundred years.

Oak, in Sweden and Denmark, is reputed quite intolerant, and is managed with this fact ever in mind. An understory of beech, hornbeam, hazel, hawthorn, alder or possibly silver fir is generally encouraged to come in under older stands, following an old forestry aphorism, " The oak should have a free crown and covered feet " [74–191].

Because of the short growing season and occasional years of early fall frost, acorns do not always mature in the Baltic region, even if a crop be borne, which is at about five to seven year intervals.

Oak is reputed to grow more rapidly than beech, spruce, or silver fir, but it falls much under all these in volume production. It is subject to about the same ills as beset the genus in America. Bark is important in the tanning industry, but prices fluctuate widely in keeping with the competition of mineral tannage and other vegetable materials. In general, forestry with oak in Sweden has followed the practice in Denmark and Germany very closely.

The stalked oak of Sweden is obviously hardier than our American red oak and can thrive under shorter growing season conditions. Acorns from that country might well be planted experimentally in Canada and colder sections of the New World, where American oaks fail or survive in a way entirely void of practical promise. Cool glacial lake regions should furnish a climatic environment very similar to those enjoyed by Swedish oaks at home.

BEECH *(Fagus sylvatica)*,—" BOK "

This tree thrives about as far north in Scandinavia as does the stalked oak, and has in the same way become more closely restricted in distribution under forest stand conditions during the past five or six centuries [74–622]. A careful investigator recently reported that in southeast Sweden the area of beech forest has diminished over 90% in 230 years. About 1800 it was the practice to clearcut the beech woods for fuel used in potash manufacture. Somewhat earlier the wood of larger trees was much sought after for making staves for the barrels in which Baltic herring were exported in huge quantities. In more recent times the dairy industry has become highly developed in Denmark and locally in South Sweden. The staves for the butter tubs or casks used must all be of beech, as its wood is clean and tasteless. All these factors have contributed to make beech less prevalent, especially where spruce overlaps its range and stands ever ready to take possession of each square foot the beech yields. It is also true that considerable areas have been planted and intentionally converted to spruce stands, as this tree is thought to yield a greater monetary return than beech. Good physical condition of soil rather than its mineral fertility is the requisite for thrifty growth of beech. It seems also more partial to atmospheric humidity than high soil moisture. Crowded stands in early life are even more imperative to beech than oak. Stands established by direct seeding in Denmark are almost unbelievably dense in the seedling and sapling stage.

The use of the wood in connection with the dairy industry of Denmark and South Sweden is the chief reason for the continuance of beech stands in these localities. The high value of the wood for fuel in a land devoid of coal also argues in favor of the tree, but in spite of all this the beech woods of the Baltic are probably doomed to dwindle in the future as in the past, even if there still exists considerable sentiment for the clean beauty of such stands and their associations with folklore and customs.

Utilization of the beech here is probably even closer than in Central Europe. Fagots and brushwood are garnered carefully, small articles are turned from wood that might otherwise go to waste, and stumps are often salvaged. The foliage and twigs are collected in early June in some localities and dyed red or purple for manufacture of wreaths and other floral pieces, as well as for interior decorative use in winter. One must admit that this material serves the intended purpose well, and often forms the groundwork of the very artistic table, wall and window dressing commonly met with in Swedish homes and public places. The use of coniferous greenery and birch shoots, forced into precocious vernation in decorative motifs, is typical of all the North countries. It exemplifies the inherent love of the people for forest things, and certainly helps effectively to render endurable the long, dark hours of winter in this region.

Beech is in high esteem with scientific foresters everywhere, due to its favorable influence on the soil. This is realized very well in South Sweden. It is often written and talked about, yet not much use seems to be made of the tree. In Denmark, on the other hand, wherever forests occur on sites good enough to grow it, the foresters aim at beech in pure or mixt stands, as a rule. As a result of above cited circumstances, the very best technique for regeneration and care of beech stands has probably been worked out here. Shelterwood regeneration, often assisted by soil cultivation, is most popular. Seeding in prepared strips and rows, or at times broadcast, is occasionally practiced. Planting nursery-grown stock is the exception, but gives good results.

The best thinning practice for beech has been a standing problem in Europe for many years. Table XLII, quoted from Wahlgren, shows the reaction of the tree on best Danish soils under unlike treatment.

This table quite clearly indicates the advantage of very heavy thinning. Even if the gain is not so great with the longer rotation; during shorter ones it approaches 30% and yields larger material. It must also be remembered that the grade (a) thinning was intensified considerably after that stand passed sixty years of age.

MAPLES *(Acer, sp.)*,—"LÖNNAR"

This genus is almost without forestal importance in Sweden. The Norway Maple (*Acer platanoides*) ranges about as far north as the stalked oak (*Q. pedunculata*), but in the forest is limited to occasional crooked specimens or clumps of undergrowth on better soils southward. The field maple (*A. campestre*) is almost extinct, though probably once fairly frequent in parts of the South. Crooked park specimens occasionally met do not especially commend the tree.

The sycamore maple (*A. pseudo-platanus*) is fairly frequent as a park and street tree in South Sweden, and is occasionally escaped. It grows quite well, as a rule. Foresters are inclined to encourage a certain representation of the broadleaf maples as an understory mixture with older coniferous stands.

TABLE XLII.—RESULTS OF DIFFERENT GRADES OF THINNING IN BEECH STANDS IN DENMARK AT VARIOUS AGES

a = Light thinning getting heavier after 60 years.
b = Heavy thinning.
c = Very heavy thinning.
(All data on per acre basis) [43]

Features of Stand	Grades of Thinning	Ages in Life of Stand			
		30 yrs.	50 yrs.	70 yrs.	95 yrs.
Number of Boles	a	1473	510	231	103
	b	1188	371	184	104
	c	677	199	99	58
Average D. B. H. (in.)	a	3.6	7.0	10.5	14.8
	b	3.6	7.5	11.1	15.0
	c	5.0	10.0	14.8	20.1
Sectional Area at Breast Height (sq. ft.)	a	103	138	139	124
	b	89	114	123	128
	c	92	109	118	129
Average Ht. (ft.)	a	36.7	58.7	76.7	93.4
	b	37.2	60.7	79.7	97.0
	c	61.7	68.0	88.1	105.4
Vol. of Stand after Thinning (cu. ft.)	a	2401	4508	5907	6673
	b	2083	3825	5452	7265
	c	2572	4381	5892	7472
Vol. Removed to Date as Thinnings (cu. ft.)	a	807	2982	5936	10164
	b	1047	3442	6200	9604
	c	1456	4336	7196	10184
Total Production (cu. ft.)	a	3208	7491	11843	16837
	b	3131	7268	11652	16869
	c	4028	8717	13088	17657
Total Mean Annual Increment (cu. ft.)	a	107	150	169	177
	b	104	145	166	177
	c	134	174	187	186

HORNBEAM *(Carpinus betulus)*,—"AVENBOK"

In the extreme southern provinces of Sweden hornbeam is native and seen as understory and marginal growth in the forest occasionally. It grows slowly, is always crooked, and attains but small size. In Denmark the hornbeam grows better than in Sweden. Foresters are inclined to favor this tolerant little tree as a soil cover crop that can be coppiced and yields valuable fuel; also as a minor-species in mixture on suitable sites.

ASH *(Fraxinus excelsior)*,—"ASK"

The northern limit of this tree in Scandinavia coincides closely with that of oak, but only in South Sweden has it forestal importance. On good sites at the extreme south, ash grows remarkably well and reproduces naturally in dense thickets, wherein the saplings often develop as straight as arrows. Even as far north as Stockholm, good groups and small stands of ash, usually mixt with other trees, are seen locally, but the rate of growth is slow and form is poor on all but the best sites.

Stands of ash thin out rapidly at a quite early age, and to a greater extent than those of other species, are predisposed to the development of a dense ground cover of rank herbaceous weeds. This is due to their occupying good moist soils and forming a rather open canopy. By theory such stands should show an understory of beech, hornbeam, maple or hazel, but in fact this is never the case except in late life when openings of large size are characteristic.

Ash is little subject to fungi in Sweden. The canker fungus (*Nectria ditissima*) deforms boles and branches at times. A little moth larva (*Prays curtisellus*) mines out the terminal buds and gives rise to forked growth.

The number of seeds per pound for Swedish ash is 6,120 to 6,600. Viability is retained two or three years. Unless seed is sown or stratified immediately upon ripening, it will not germinate during the succeeding season, (*i. e.*—if it is permitted to dry out thoroughly).

Scandinavian ash seed should be experimentally planted in Canada, north of the limits attained by white ash (*F. americana*), and on the Pacific Slope. It is logical to expect success with this species and its local strains under climatic conditions unsuited to any American trees of this important genus.

ELMS *(Ulmus, sp.)*,—"ALMAR"

Three species of elm are native in Sweden, but two of these (*U. campestris* and *U. effusa*) were always limited to a narrow area of the warmest south provinces and are now very rare, except as shade and ornamental trees. The forest elm or Scotch elm (*U. montana*) has a relatively wide range, being found further north than oak in the mountains of southern Lapland, but as to forestal import it plays a rôle only south of Stockholm, and that a minor one at best. The hardiness of this tree respecting every climatic influence commends it to the attention of plant introducers seeking species for northern localities adverse to tree growth. It is, however, a rather exacting tree as to mineral fertility, doing poorly on acid sites.

Wood is strong, durable, flexible, rather heavy, and difficult to split.

The canker fungi (*Nectria cinnabarina* and *N. ditissima*) attack the elms but are not serious. An insect (*Schizoneura lanuginosa*) [74–669] very commonly causes club-shaped galls on the leaves, similar to those seen on American slippery elm (*U. fulva*).

LINDENS *(Tilia, sp.)*,—"LINDAR"

The three species of linden commonly distinguished in Europe all occur native in Sweden, but are of very little importance to forestry. The small-leaf linden (*T. parvifolia* or *cordata*) and large-leaf linden (*T. platyphyllos*) are naturally limited to local outposts near the south coast, but the common linden (*T. vulgaris*) ranges further north than oak, although it rarely attains tree size much north of Stockholm. The other two species are common park and street trees in that city and neighboring towns. The small-leaf species has the absolute distinctions of smooth leaf-stalks and lower leaf-surfaces except for tufts of rusty hairs in the axils of the nerves. The lower sides of the leaves also show a typical blue-green color. This color is the chief distinction between the small-leaf tree and the common linden. The tufts of hair in the axils of the leaf veins are more gray than rusty in the common linden. The large-leaf linden grows more rapidly than its relatives. Its larger leaves are grass-green and rather evenly dusty pubescent beneath.

Except for the theoretical interest foresters take in the linden because of its ability to endure shade and sprout vigorously from the stump, it plays no rôle in Swedish forest management. In the south, with willows and poplars, it is often pollarded.

Wahlgren [74–677] states that many of the seeds of the European lindens will germinate the first season after ripening if they are fall-sown and not permitted to dry out before-hand. This is an advantage over American species (particularly *T. americana*), where the "after ripening" requirements inhibit growth in spite of any possible treatment.

THE ALDERS *(Alnus, sp.)*,—"ALAR"

The black alder of Europe (*A. glutinosa*)—"klibbal," is a rather common tree of moist sites in Sweden up to about the latitude of Uppsala. From thence through Central and North Sweden, the gray alder (*A. incana*),—"graalen," replaces it as a forest tree, altho occasional black alders may be met much further north. These two trees are extremely hardy, or in fact nearly indifferent to climate. Their great requisite is soil moisture, but it is erroneous to think that they will thrive in a stagnant swamp. Their ideal habitat is the overflow lands in fertile stream valleys. They can stand for months with their entire root systems immersed in water and thrive if the latter be in motion and capable of supplying a certain amount of oxygen. A modicum of soluble calcium seems requisite to thrifty growth.

Gray alder goes up to timber-line in Scandinavia generally and is found on considerably drier sites than its larger relative of the south. In the far north, growth is naturally scrubby, but under more favorable conditions it may attain a height of fifty feet or more and exhibit good form. The gray alder is at times a curse because of the rich crop of sprouts and root suckers that come up when it is cut off. Land-clearing projects and coniferous plantations may be much impeded by the persistent growth of this tree.

Both the alders may be grown from cuttings made of rapid growing sprout wood. Cuttings [74–704] should have a little four-year wood at their base and the tip should be two-year wood. They should be set deep enough in the ground that about two inches of the tip projects.

These trees are soil improvers and support on their roots symbiotic bacteria (*Frankia alni*) whereby atmospheric nitrogen is fixed in the soil.

The gray alder (*A. incana*) is native over much of North America, but rarely exceeds ten feet tall. It would be interesting and possibly of practical value to introduce the North European strain of the species to our stream banks to determine if it can here retain its ability to grow rapidly in early life and attain true tree size.

Black alder (*A. glutinosa*) has been grown for some years in New York and Pennsylvania. It shows great thrift, but has been destroyed on several areas near Reading, Pennsylvania, by the attacks of a small bark borer.

The alders are of little significance to forestry in Sweden, despite their occurrence over the whole land. Their wood is held in low esteem and small areas of half swamp or stream margin growth managed as coppice for fuel are the usual status of the tree. In Denmark the alders have both been used more or less as nurse trees and soil improvers under intensive forest management, also in high forest stands on suitable soil under rotations of fifty to sixty years. The volume yield from alder is good, even if the quality and utility of the wood is low. The type of stand management best adapted to alder is illustrated by the record of a Danish sample plot which at sixty-eight years of age had a volume of but 2,115 cu. ft. per acre, but from which, during that time, 8,818 cu. ft. had been taken as thinnings. This was a total production of 10,933 cu. ft. per acre, or a mean annual increment for the whole rotation of 161 cu. ft. This yield was from the best quality site and emphasizes the last extreme in heavy and persistent thinning.

Aspen and Poplars *(Populus, sp.)*,—"Asp och Popplar"

The European aspen (*P. tremula*) is biologically very similar to the trembling aspen (*P. tremuloides*) of America. It ranges from the ocean to timber-line in Scandinavia and is able to maintain itself on nearly any site. Still, good fresh soil is required for satisfactory growth in terms of quantity or quality.

The wood of aspen is the raw material for the manufacture of safety matches, in which industry Sweden leads the world. For this use wood must be free of serious decay, cankers, knots and crooked fibre. In bygone years these matches were made entirely of Swedish grown wood, but of recent years it has been necessary to import more and more of the supply from Finland and other Baltic states, due to the low grade rather than decreased domestic offerings.

A few years ago an investigation of the low quality of Swedish as compared to imported aspen, traced the trouble back to conditions under which the supply is now grown. Decay is usually due to fungi that gain entrance to trees through stem or root wounds. Both these types are mainly caused by grazing animals. Aspen wood is utterly lacking in durability, and small wounds may be the cause of serious infection under conditions adverse to prompt healing [13]. Most aspen stands originate as root-suckers from the very extensive and quite superficial root systems of some older tree. This means that large groups of trees are often all more or less united and grown together underground, due to origin or root-grafting. They are for this reason highly predisposed to calamitous attacks from such fungi as spread underground, (*P. radiciperda* and *Armillaria mellea*). The hoofs of grazing animals on the moist, humus soils prevalent in Sweden have been proven to cause considerable wounds upon the shallow lying roots of this tree.

Some silviculturists, with good reasons, maintain that aspen wood should be produced in stands mixt with conifers, or even other hardwoods, and should be of seedling origin, instead of vegetative origin and in pure groups and stands as is predominantly the case. Such a system of management requires the nearly complete elimination of the species from areas before regeneration, otherwise root-sucker growth will usually crowd out nearly all seedlings. This end can be attained by cutting out aspen at least ten or fifteen years before the rest of a stand is to be removed. In matter of seed, this tree is fortunate, as they are so small, light and abundantly produced, that two or three good trees of desired sex and proper location should almost suffice to seed up a whole township.

To protect a growing stand from fungus attacks, thinning and pruning at intervals of four to eight years, depending upon age, is advised. This practice is continued until about three-fourth of the rotation is past, and special care is taken to remove any trees that show signs of incipient decay or decreasing vigor.

Pruning should be done carefully so wounds heal in the minimum of time.

Aspen is considered a fairly desirable nurse tree by Swedish foresters. Older stands of the tree come in naturally to spruce, as a rule. This is a fortunate circumstance in general, since it would not usually be good policy to grow successive crops of this tree on a given site.

Among the poplars introduced to Sweden and holding forth considerable promise are the American cottonwood (*P. deltoides* var. *canadensis*), balsam poplar (*P. balsamifera*), and the Asiatic poplar (*P. laurifolia*). All these trees grow rapidly, are hardy, and yield wood acceptable to the match manufacturers.

UNIMPORTANT TREES AND SHRUBS OF THE FOREST

The European hazel (*Corylus avellana*),—" hassel," has about the same range in Scandinavia as the stalked oak. At one time since the Glacial Age it occurred much further north than at present, according to remains frequently uncovered in bog deposits. Whether its elimination from these areas was due to climatic changes or increasing swampiness and competition of the tolerant and aggressive spruce is an open question. The tolerance of this hazel is quite notable, also, and gives it a certain value as a soil cover crop in older stands of conifers. Seedlings grow rather slowly and show bushy form, but sprouts develop very rapidly into straight sticks of small size that serve numerous domestic uses and are an effective fuel. Recent studies by Prof. Hesselman [19–252] show that hazel yields litter of very desirable character in connection with the maintenance of forest productivity.

European mountain ash (*Sorbus* or *Pyrus aucuparia*), " ronner," is universally found in Sweden in forests and pastures. It is in general quite similar to American mountain ash (*S. americana*), but attains larger size. A height of thirty feet is not unusual.

This little tree is a darling of the Scandinavian landscape. It cheers every passerby with its wealth of white bloom, attractive foliage and gorgeous fruit. The latter is a benison to all wild life and is at times collected to supplement the winter fare of sheep, swine and poultry.

This mountain ash grows rapidly in early life, due doubtless to its wide-extended but rather weak and flat root system which seeks out effectively the most fertile pockets of soil near the spot of germination. This faculty enables it to grow fairly well on rocks, logs and stumps where existence during the first year or two seems little short of miraculous.

Because of its hardiness respecting cold and wind, relative indifference to soil and general importance to the fauna of the land, foresters look very kindly on the mountain ash. It is undoubtedly a pioneer species of some importance, and northern strains might well be introduced to America, where forms of the tree with a more southerly ancestry are already sometimes met as escapes.

The white beam tree (*Sorbus aria*) and its near relatives (*S. scandica* and *S. hybrida*), " oxlarna," are occasionally found wild in South and Central Sweden, but are more frequent in ornamental plantings. Some of these trees are a foot in D. B. H. and forty feet tall. Their fruits are in appearance similar to a small crab-apple, but in taste, consistency and other features more like mountain ash berries. Their entire dentate-serrate leaves are glossy green above and woolly beneath. All species are very hardy, but desire fair to good soils. On the west coasts of Denmark and Norway, where considerable forest plantings have been made and show serious damage from the incessant strong salt winds, these trees stand fresh and uninjured. None of these species seem capable of competing very successfully in nature, but are interesting from the standpoint of a food supply for game and bird life.

The bird cherry of Europe (*Prunus padus*), "hagg," is common thruout South and Central Sweden on better soils. It is similar to the choke cherry (*P. virginiana*) of East America in every respect, but exceeds the latter in size attained. This tree is fairly tolerant and is undesirable in the neighborhood of spruce stands of seeding age, as it is the alternate host of the spruce cone rust (*Pucciniastrum padi*). Swedish folks, however, look on this tree with considerable sentiment. It is especially beloved of women and children because its fresh, green leaves are the first to be unfurled and definitely forecast the approach of the delightful northern summer.

This bird cherry could probably be introduced readily to our American forests, but it possesses no peculiar virtues to recommend it above our native species.

In the neighborhood of Stockholm and some other localities in Sweden one meets very commonly the American red-fruited elder (*Sambucus racemosa*) and June-berry (*Amelanchier canadensis*). Both grow luxuriantly and fruit heavily. They are both being distributed far and wide by birds and are very desirable contributions to the woods and waysides. The June-berry in its adopted home seems highly favored by climatic conditions, as it looks so thrifty and vigorous as to be identified with difficulty. In Sweden it ripens fruit late along in August. Berries are larger and more juicy than in America, but not so sweet.

Among shrubs or small trees native in Sweden and rather important to the protection and food supply of bird life, the following are important: Wild apple (*Pyrus malus*), "Vildapel," Hawthorn (*Cratægus oxycantha*), "hagtorn," alder buckthorn (*Rhamnus frangula*), "brakved," common buckthorn (*R. cathartica*), "vägtorn."

Most of the low woody shrubs of the forest floor in northwest Europe are common also to similar northern climates in America, or else they are replaced by nearly like species in the same or a closely related genus. Examples of common circum-boreal species are: (1) mountain cranberry (*Vaccinium vitis-idæa*), "lingon," (2) cranberry (*V. oxycoccus*), "tranbaer," (3) big whortleberry (*V. uliginosum*), (4) diapensia (*Diapensia lapponica*), and (5) wild rosemary (*Andromeda polifolia*), "rosmarinlying."

Heather (*Calluna vulgaris*), "jung," and the blueberry of Europe (*V. myrtillus*), "blabaer," are among the commonest forest ground cover shrubs not found in America. Neither of them are considered favorable to the welfare of the forest. They not only indicate fertility depletion and high acidity of the surface soil, but also contribute toward this sort of deterioration. In all probability their residues are to a certain degree responsible for the development of the forest hardpan ("podsoleringen"), which has much reduced the productive capacity of large areas of European forest soil. In general, all plants of the family *Ericacea* (heaths and huckleberries) yield highly acid litter and tend to bring about a rapid leaching of soluble minerals from the surface soils with deposition a little deeper down. This horizon of deposition may finally, after lapse of long years, become quite impermeable to tree roots and nearly impervious to water.

CHAPTER VI

FOREST ECONOMICS AND STATISTICS

The foregoing chapter has given some facts concerning the woody flora of Sweden in particular and Scandinavia generally. It has not given much idea, however, of the relative importance of the several tree species in respect to the creature comforts and industries of the Swedish people. Facts which follow show definitely the status of Swedish forests from many standpoints and how intimately the domestic welfare and international standing of the country is bound up with forest production.

In the forestry museum connected with the College of Forestry (" Skogshögskolan ") at Stockholm, Professor Lundberg has organized a very instructive display of articles manufactured from native woods of different kinds. The below table, XLIII, cites the number of different articles made of each kind of wood. It is realized that the table may be misinterpreted, since many of the articles are of minor importance; yet even these illustrate forcefully the large place wood occupies in daily life and how we use it at every turn from cradle to coffin.

TABLE XLIII.—Variety of Uses of Swedish Woods

Kind of Wood	Number of Articles Made in Whole or Large Part of Each
Pine	65
Spruce	48
Birch	57
Beech	39
Oak	36
Aspen	18
Elm and Maple (each)	16
Linden	12
Ash and Willow (each)	8
Common Juniper	8
Mtn. Ash and Alder (each)	8
Pear and Hazel	4

Note:—All the many articles in this display bear cards giving reasons why the wood from which it is made is especially adapted to the purpose.

FOREST PRODUCTION AND INCREMENT [22–292]

Table XLIV, after Prof. Tor Jonson, is probably the best extant catalog of the wood production of Swedish forests during the years following the World War. While that struggle was in progress, from 20% to 30% more wood than the usual cut was harvested [45–60]. The pre-war cut was little less, and in boom years possibly a little higher than the present average annual production. Wood substitutes, closer utilization and decreased purchasing power of certain consuming countries have tended to offset the increased requirements of the pulp and paper industry.

TABLE XLIV.—Wood Cut of Sweden by Major Uses

Wood Users		Volume Requirements per Yr. (cu. ft.)	
Domestic Uses			
Fuel for rural districts	355,278,960		
Fuel for towns and cities	75,223,080		
Timber used in rough	117,249,120		
Total		547,751,160	
Industrial and Export Uses			
Logs exported in excess of imports	23,308,560		
Lumbering for saw-mill	514,907,280		
Total	538,215,840		
Fuel and pulpwood to be deducted	40,260,240		
Net requirements of saw mills	497,955,600		
Pulpwood	238,029,840		
Charcoal	141,264,000		
R. R. Ties and poles	14,126,400		
Fuel for R. R. and shipping use	17,658,000		
Fuel for industries in excess of offal	35,316,000		
Total for Industries and Export		944,349,840	
Total of All Wood Actually Used		1,492,101,000	
Waste and decay in the forest		96,413,000	Per. C.f.
Total drain on the forests	pole, mill 6	1,588,514,000	265
Present estimated increment		1,183,086,000	197
Present overcutting of Swedish Forests		405,428,000	
Normal increment of forests when age classes are properly represented		1,656,320,400	

From this table it is seen that Swedish forests are being overcut by nearly 35% per year, but that this is not a serious matter, since it will be remedied automatically in two or three decades, when the steady cutting removes the very considerable volume of hyper-mature growing stock in north and interior Sweden on which there is now no net increment. It is there, also, that most of the loss due to decay occurs.

In addition to the gain in increment merely because of correcting age class distribution defects, increased adoption of rational thinning practices will speed up growth to a certain extent, as will also the use of better regeneration methods. Then, too, the drainage of marsh and bog lands will result in great permanent gains to forest growth. There is estimated to be 2,545,130 acres of these lands, whose reclamation is economically feasible, which are in private ownership and under the supervision of the Forest Protection Boards of the country. Associated with these lands and under the same conditions of ownership and supervision are 3,044,272 acres of drowned (försumpade) forests with low increment and a tendency to still further deteriorate. All this land can usually be drained quite readily by the simple process of stream cleaning, and is thus very greatly increased as to productivity. Fortunately, these areas in need of drainage are often located in large contiguous tracts, so it is possible to execute comprehensive work on a plane of maximum efficiency.

LARGE AND SMALL FOREST OWNERS

The character of forest management that will prevail in any land is usually decided to a great degree by the conditions of ownership. The traditions, economic status and intelligence of the owner in conjunction with taxation and public policy may make or mar the forest. It has been pointed out under the heading of forest ownership that 78% of all Swedish forests are privately owned. Of these private lands, 36% belong to corporations, 6.3% to large individual owners, and 57.7% to farmers and small holders with properties less than 247 acres in area, or $53,333.00 in assessed value [52–11). This means that almost half the productive forest lands in Sweden may be considered in the status of " farm woodlots," or small properties partaking of their nature.

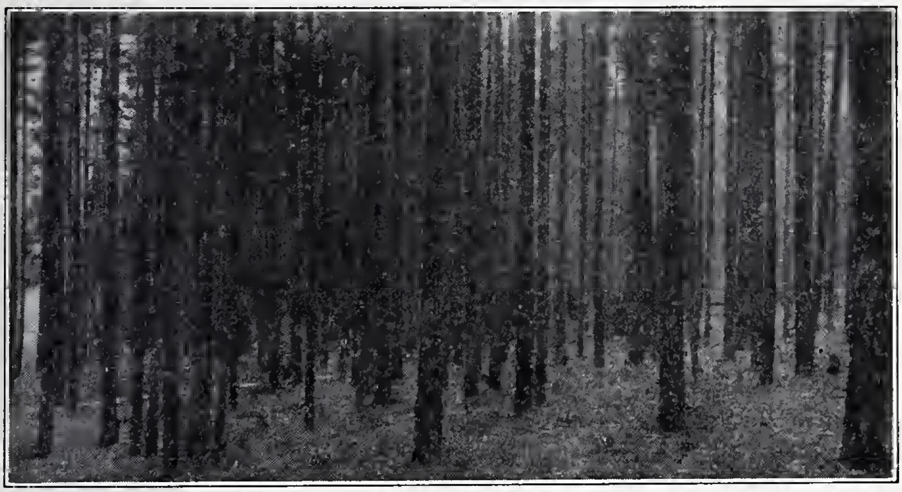

Fig. 6.—Pure Pine Growth; An Important Forest Type in Sweden. Such stands as this are quite common on the poorer soils in Central Sweden. They are quite satisfactory as to volume of wood yield. but would probably be improved by the intermixture of some birch and spruce.

It has been a common complaint in Central Europe, and even France, that the peasant-owned woodlands are poorly handled or often abused. This charge has recently been made in Sweden, and is fairly proven by Schager. It is also heartening to foresters there when they note the applause and satisfaction with which large forest owners and corporation officials, or shareholders, greet the statement that their large holdings are now more productive and better stocked than the woodlots of the farmers. For it was these woodlot owners who were chiefly responsible for passing laws that compelled corporations and big private owners to cease their practice of ruthless devastation, such as still prevails in American lumbering generally. At the behest of foresters and men of vision in every walk of life, largely by farmer votes, a considerable measure of compulsory forestry has been in force since 1903.

The truth as to the general status of small forest properties or woodlots is embraced in the phrase "mediocre management." The farmer rarely abuses his property or permits the soil to deteriorate to the extent corporation, short-sighted lumbermen and stumpage speculators commonly do when the strong arm of society fails to exercise a steadying and warning restraint. On the other hand, the big holder of forest land can usually make a greater success of forestry as a business for several simple reasons. The factors for success in forestry have all been taken advantage of by the large owners in Sweden. (1) They have often profited by vertical organization of enterprises. (2) Forestry is essentially a big business, and capital on better terms is available to the large owner. In fact, where sustained yield is achieved, borrowing of money to meet taxes or to finance reforestation is usually unnecessary and not considered in the equation. (3) Waste is eliminated and favorable market conditions are made to serve their turn. (4) The most efficient technical training is brought to bear on the problems that arise.

The data in Table XLV is given to illustrate the proportions existing between cleared and forested land on farm properties in the several provinces and regions of the country. It also gives the approximate total area of the larger farm properties, not including large landed estates. From this table can be calculated the average cleared area for the larger general farms in each Swedish province and for the country as a whole. To an American, the size of clearings will seem small, being but approximately twenty-six acres, yet even this includes considerable pasture land unfit for the plow. It must be remembered, however, that many Swedish farms are utterly devoid of woodland, and hence were not used in the derivation of Table XLV.

The size of woodlots in Sweden would seem to average high enough to justify good management. In fact, the care given these forest areas usually leaves little to be desired to the eye of an American. Yet grazing is often overdone and the growing stock has been reduced below the optimum. There has always been a tendency, as in America, for the purchaser of a property, who lacks means to pay for it, to turn to the forest; cut this all off, so far as merchantable material is concerned, and then take no adequate measures to guarantee a satisfactory regrowth.

It is also noticeable that small forest owners are rarely able to drain lands, or do so as effectively as large land holders. The latter can execute a comprehensive plan that will permit afforestation of extensive marsh or bog areas and greatly stimulate growth of " water-sick " stands adjacent. This work means much to the forest production of such boreal lands as Sweden.

The use of wood on farms is a matter of vital interest to forest economists. It has recently been stated that the farms of the U. S. are the heaviest consumers of the cut from our forests [12–42]. Some years ago a committee of specialists studied the consumption of wood on the farms of the province of Värmland with very interesting results. This province includes three climatic zones and is fairly typical of all Sweden. Its northern portion is similar in conditions and development to Norrland, the central section shows the alternation of field, pasture and woodland common to Middle Sweden, while the southern part has large contiguous expanses of cultivated land characteristic of South Sweden.

TABLE XLV.—AVERAGE AREAS OF SWEDISH FARMS HAVING WOOD-LOTS AND SIZE OF THE LATTER BY PROVINCES [52–24]

Province	Region of Sweden	Average Farm Areas (acres)	Average Area of Woodlots (acres)
Malmöhus	South	27	2.5
Kristianstads	South	50	25.
Blekinge	South	73	49.
Hallands	South	60	30
Kalmar	South	126	95
Gottland (Baltic Island)	South	71	47
Kronoberg	South	89	67
Jonköping	South	112	90
Södermanland	South	90	60
Östergötlands	South	112	74
Älvsborgs	South	83	62
Skaraborgs	South	50	25
Gothenburg and Bohus	South	45	30
Stockholm (City)	Central	74	12.5
Stockholm (Province)	Central	106	79
Uppsala	Central	100	50
Gävleborgs	Central	131	112
Västmanland	Central	112	75
Kopparbergs	Central	126	110
Örebro	Central	70	35
Värmland	Central	96	77
Västernorrland	North	132	117
Jämtland	North	284	269
Västerbotten	North	193	161
Norrbotten	North	149	112
All Sweden		103	77

Data on the absolute requirements of wood for fuel and other purposes are given later under *Utilization,* but in Table XLVI are relative figures showing the preponderant importance of fuel among the uses of wood on the Swedish farm. This importance may not

TABLE XLVI.—USE OF WOOD ON FARMS OF VÄRMLAND, SWEDEN, AND ORIGIN OF SUPPLIES

Kind of Use	Origin of Wood Used					(By % of Volume)				
	Boles of Living Trees					Dead Trees	Limb Wood	Old Wood		Totals
	Conifers	Birch	Other Hard Woods	Saw Mill Offal	Total			From Bldgs.	From Fences	
Fuel	21.06	23.36	9.13	2.52	56.07	5.17	10.88	3.30	1.85	77.27
Buildings	11.10	.03	.02		11.15					11.15
Fences	8.35	.17	.41	.07	9.00	.01	.27			9.28
Drains and Bridges	.40				.40					.40
Racks for Drying Hay	1.32	.01	0.1		1.34					1.34
Home Manufactures	.20	.18			.38					.38
Miscellaneous	.18				.18					.18
Totals	42.61	23.75	9.57	2.59	78.52	5.18	11.15	3.30	1.85	100%

prevail in lands with vast resources of coal, oil or gas, yet in many localities the American farmer, too, will always rely in whole or to a large degree on the forest for fuel.

From this table it appears that nearly 80% of the wood used on the farm is cut from stems of trees, that might have a possibility to develop into valuable merchantable material, if not cut in the shape of thinnings. It is especially notable that nearly 45% of all fuel used on farms has its origin in bolewood. Even if these trees be cut as thinnings, it is still likely that the material would have an immediate and direct market value in a locality where charcoal and pulpwood find a ready demand. It is probable, therefore, that Swedish farmers are about as short-sighted and poor economists as many of their American brethren, and not at all worthy to be compared in thrift with the rural folks of Central Europe, France, Denmark and the Low Countries.

Schager [52–55], after careful study, estimates the use of wood by the small farmers of Sweden in Table XLVII.

These figures for farm wood consumption are probably low when one takes into consideration the Swedish climate and much greater use of wood in Canada, U. S. A. and Finland. (See Table XXII.)

TABLE XLVII.—USE OF WOOD BY SMALL FARMERS

Locality	Annual Quantity per Farm (cu. ft.)
Interior and Upper Norrland	1589 to 1766
Middle and Coast Region of Norrland	1413 to 1589
South Norrland and North-Central Sweden	883 to 1059
Middle Sweden	530 to 706
South Sweden	353 to 530

The same authority next takes the average productivity of forests in the several forest regions of Sweden and shows the area of well managed and average good forest necessary to supply a farm with the wood it needs. The figures in Table XLVIII bring out very forcefully the great aggregate area of forest whose increment is required by the farms.

TABLE XLVIII.—FOREST AREAS REQUIRED TO SUPPLY HOME NEEDS OF SWEDISH FARMS

Locality	Area Required per Farm (acres)
Interior and Upper Norrland	about 74
Middle and Coast Region of Norrland	37 to 62
South Norrland and North Central Sweden	25 to 37
Middle Sweden	12 to 25
South Sweden	7½ to 12

It should be said, in justice to the small farmer in Sweden, that he has often had to struggle against very adverse economic conditions. He has not, as a rule, been well informed concerning the value and methods of marketing the products of his woodland. Within the past two decades real progress has been made toward better forestry on these small properties. The provincial Forest Protection Boards deserve great credit for the increasing popular appreciation of the problems and possibilities of the woodland.

A little less than 5% of all Swedish forests are now held by large individual land owners. These are the estates of the defunct nobility for the most part; altho in a good many cases large properties have been acquired by persons of wealth who made their accumulations in commerce or the industrial field. In nearly every instance, forests held by this class of owners are well managed. In fact, on these estates and on church forests one meets about the only instances in South Sweden where excess growing stock and over-mature stands are being held, probably for sentimental or æsthetic reasons.

The oldest examples of rational forestry in Sweden were found on some of these estates. Their owners were often highly cultured and well informed. They were disciples of Linneus in their feelings toward the natural world, or had a first hand knowledge of the forestry practices prevalent in Germany and adjacent lands. The forests of Central Europe were taken as a model. German foresters were employed in quite a few cases, and it is not unusual to find in old family archives, very carefully drawn forest working-plans with the felling budget (annual cut) fixed to the cubic foot for 20, 40 and even 100 years in the future. These plans, drafted at great expense, invariably fell into disuse because developments soon put them " out of step " with conditions actually at hand in the wood. Today the management of these properties is rather variable. Foresters in private practice sometimes plan the cutting, planting and other work. More often, probably the foresters of the provincial Forest Protection Boards are employed to give technical advice. In some few cases, owners or members of their family have studied forestry and delight in its practice.

TABLE XLIX.—Products Sold from Estate Forests (by Volume)

Products	Estates near Large Cities	Near Iron Furnaces	Estates Otherwise Located	Averages for All
Timber	36.6%	67.1	42.7	48.7%
Pulp-wood and Mine Props	4.4	4.6	32.9	8.
Charcoal Wood	4.5	19.2	3.9	9.8
Fuelwood	53.2	8.9	15.2	32.1
Miscellaneous	1.3	.2	5.3	1.4
	100%	100%	100%	100%

Schager [52–112] has assembled data for the private estate forests of Sweden, showing the character of products cut in keeping with location and industries. See Table XLIX. It demonstrates that good business principles prevail.

Schager also made an intensive study of forestry on a number of representative estates in South and Middle Sweden, from which he compiled Table L, showing the care given the developing stands and giving a picture of the growing-stock conditions.

From Table L it is plain that thinning practice, the best earmark of rational forestry, is well established on these estate forests. The thinning percentage is very high for those properties with growing stock of low average age. Not even in Central Europe will it appear that intermediate cuttings make up a greater proportion of the forest yield. It must be remembered, however, that the percentage of wood cut as thinnings is inordinately high when the growing stock is unbalanced in the direction of over representation in the younger classes, and as normal stocking is approached it will be somewhat reduced unless still more intensive management is adopted.

TABLE L.—GROWING STOCK AND THINNING ON ESTATE FORESTS

Total Area of Forests Studied (Acres)	Total Annual Cut (cu. ft.)	Growing Stock in % of Normal for a Like Area of 70-yr.-old Growth	Volume of Thinnings as % of the Total Annual Cut
50,982	1,712,000	10 to 30	57
23,734	852,000	30 to 50	59
13,170	723,000	50 to 60	45
45,756	2,469,000	60 to 70	25
15,444	488,000	~~60~~ to ~~70~~ 70 80	~~25~~-20
149,086	6,244,000		40%

The intensity of silviculture on these estate forests can be judged fairly well from the fact that 29% of the whole acreage to be regenerated on these properties was seeded or planted, on 10% the soil was cultivated to assist natural seed regeneration, and 61% was reproduced by unaided nature.

During the war years (1915–1920) there was considerable lamentation in Sweden because speculators often purchased well-stocked estate forests and similar properties, and as prices for all sizes of wood rose rapidly, they wrecked and denuded these forests with utter disregard to the future. In many cases these speculators bought only stumpage rights, but often they had ready and easily earned money to invest and preferred to put it into real estate. This was especially true when the speculator was of the tradesman class. About 30% of these undesirable business men were sawmill owners and preferred to follow their usual custom of stumpage purchases, but were anxious to buy without restriction on their operation, so it was possible to take full advantage of the exceedingly high fuelwood market.

The Forest Protection Boards in nearly every province had much trouble with such speculative gentry during and following the war period. They used all manner of subterfuges and resorted to the courts in order to relieve themselves of the responsibility of re-establishing acceptable forest stands. The courts, in the end, invariably sustained the Forest Protection Boards, and much good regeneration work was executed by these speculative owners, but sometimes it was so long delayed that the areas became overgrown with shrubs and herbaceous weeds or the soil deteriorated, due to exposure. In some instances such large tracts had been clearcut that it was impossible to secure suitable seed and labor for reforestation at the time this should have been executed.

CORPORATION FORESTS IN SWEDEN

In 1919 the Land Commission listed 1,748 stock companies and limited partnerships that held property in Swedish forests [52–175].

On the forests owned by private corporations in Sweden is found, in general, very good rational forestry. This was probably not always the case; the data in the tables that follow prove beyond peradventure that these forests are as well managed as any in Sweden.

TABLE LI.—Growing Stock Averages for Several Regions of Sweden

Locality	Stock, Cubic Ft. per Acre of Productive Soil		
	Crown Forests	Corporation Forests	Communal Forests
Upper Norrland	500– 586	572	500
Middle Norrland	600– 700	715	644
South Norrland	758–1030	858	786
North Central Sweden	815	1072	858
South Central Sweden	1316	1144	858
South Sweden	1144	1000	644

Table LI is based on studies by Schager and Prof. Tor Jonson, and contrasts growing stock conditions for all Sweden on property where good forestry is unquestioned.

When an exceedingly careful study was made, some years ago, covering the forests of the province of Värmland, the commission concerned reported age-class conditions for corporation owned for-

TABLE LII.—Age Class Representation on Forests Owned by Private Corporations in the Province of Värmland (West-Central Sweden)

Age-Classes	% of Total Forest Area
1– 20 yr. stands	12.21%
21– 40 yr. stands	20.76
41– 60 yr. stands	19.05
61– 80 yr. stands	12.41
81–100 yr. stands	6.67
Stands over 100 years old	5.70
Stands of mixed age (Selection forest)	18.79
Blank Areas	4.41
Total	100%

TABLE LIII.—GROWING STOCK AND ANNUAL CUT ON FORESTS OWNED BY PRIVATE CORPORATIONS

Locality	Growing Stock (cu. ft. per Acre)	Average Annual Cut	
		(cu. ft. per Acre)	% of G. S.
Upper Norrland	572	8.58	1.50
Middle Norrland	715	17.73	2.48
South Norrland	858	21.74	2.53
North Central Sweden	1072	31.46	2.93
South Central Sweden	1144	42.47	3.71
South Sweden	1000	44.32	4.43

ests in that province as given in Table LII. These age-classes lack considerable of being normal, yet they are fairly satisfactory and represent more than average good forestry in a locality where grazing and strong market demands tend to reduce the growing stock to a minimum and give rise to increasingly large blank areas.

Cutting, at least during recent years, on lands of private corporations has been very conservative, as will be noted from Table LIII.

TABLE LIV.—INTERMEDIATE CUTTING (THINNINGS) ON CORPORATE OWNED SWEDISH FORESTS IN SEVERAL LOCALITIES OF THE COUNTRY

Upper Norrland

Intermediate cuttings yield 5% to 15% of the total cut.

Middle Norrland

On 80% of the forests, intermediate cuttings yield 12% of the total cut.
On 20% of the forests, intermediate cuttings yield 20% of the total cut.

South Norrland

On 38% of the forests, intermediate cuttings yield 5% of the total cut.
On 4% of the forests, intermediate cuttings yield 20% of the total cut.
On 40% of the forests, intermediate cuttings yield 25% of the total cut.
On 11% of the forests, intermediate cuttings yield 30% of the total cut.
On 7% of the forests, intermediate cuttings yield 40% of the total cut.

North Central Sweden

On 35% of the forests, intermediate cuttings yield 20% of the total cut.
On 17% of the forests, intermediate cuttings yield 40% of the total cut.
On 44% of the forests, intermediate cuttings yield 50% of the total cut.
On 1% of the forests, intermediate cuttings yield 60% of the total cut.
On 3% of the forests, intermediate cuttings yield 70% of the total cut.

South Central Sweden

On 55% of the forests, intermediate cuttings yield 40% of the total cut.
On 5% of the forests, intermediate cuttings yield 50% of the total cut.
On 29% of the forests, intermediate cuttings yield 75% of the total cut.
On 4% of the forests, intermediate cuttings yield 80% of the total cut.
On 7% of the forests, intermediate cuttings yield 85% of the total cut.

South Sweden

On 4% of the forests, intermediate cuttings yield 50% of the total cut.
On 23% of the forests, intermediate cuttings yield 65% of the total cut.
On 58% of the forests, intermediate cuttings yield 75% of the total cut.
On 15% of the forests, intermediate cuttings yield 90% of the total cut.

In all probability the cut given is very close to the figures for increment. It may seem low for North Sweden (Norrland), but due to the high representation of all hyper-mature and very slow-growing, or actually deteriorating stands, in this region, the average increment of the forest is quite low; as will always be the tendency because of adverse climate. Replacement of old stands with new will, however, improve the increment, hence overcutting is justifiable. In the first four localities mentioned in Table LIII, the State Forest administration is cutting on the average 40% more than the actual increment of their stands.

One of the best indices to the intensity of forestry is the extent to which thinning is practiced. In Table LIV is given the result of a detailed study by Schager [52–199] that sets forth most emphatically how well established and important intermediate cutting has become in the forestry of Swedish corporations.

In Table LV are data to show the proportion of the cut from forests of private corporations that go into the several important products. It is notable that the paper industry has become so well established in the extreme north.

TABLE LV.—Chief Products from Corporation Owned Forests of Sweden by Localities

Locality	Timber	Paper-wood Mine-Props	Wood for Charcoal	Fuel Wood	Other Products
Upper Norrland	55%	30%	7%	8%	
Middle Norrland	59	38	1	2	
South Norrland	54	34	9	3	
North Central Sweden	46	22	24	7	1%
South Central Sweden	27	28	24	4	4
South Sweden	29	13	21	24	13

No special conclusions as to silviculture or form of trees grown in the various localities of Sweden can be drawn from Table LV, as it is generally the practice of most industrial corporations owning forests to manage them with the object of supplying their needs as to raw materials. Some exceptions exist, however, where a corporation cuts and sells the product of its forest for whatsoever use brings the greatest income, while its raw materials of wood or timber are bought in the open market. Yet, in every case, there is not the least doubt that the forest lands owned are held as a guarantee of the corporation's stability, and as a source of raw material in times of scarcity and high prices. These lands are a weighty factor in the play of economic forces that fix general price levels for raw materials from the forest. Every producer realizes that there is no possibility of boosting prices to the extent of unfairness, when the consumer owns a standing stock sufficient to supply his needs for a decade or two. The result is stable prices, in general very near actual cost of producing the raw materials in question.

Realization of the economic importance of insuring an industry of a considerable, or major part, of its raw material requirements, seems to be largely lacking in America. It is a development that has already started, however, and is sure to continue, inuring most certainly to the vast benefit of forestry. The fact that much of our woodland is still owned by large holders and often lies in contiguous tracts should be very favorable to progressive and far-sighted corporations, who take this conservative forward step.

The directors of Swedish wood using corporations are well aware of the great advantages derived from ownership of large areas of productive forest. They have striven very diligently during the past two decades to get all the " trump cards in their hands " by purchasing land, especially where it will consolidate their holdings, and by getting prompt and complete reproduction of the forest on all areas cut over [52–231]. The good forestry practiced by most corporations has become a matter of course, so that instead of lagging behind, they now lead the way in practical forestry in both Sweden and Norway. From almost every province of the former land, the provincial forester [52–282] testifies to the good management on forests under this type of ownership. With passage of time and a little legal compulsion on forest owners in America, it should not be too much to hope that woodlands held by paper-mill, sawmill, coal-mining and similar industrial concerns, may become models of productivity and beauty in the future, instead of presenting such disgraceful waste and ugliness as has often prevailed in the past. Swedish state forests especially interest America, because their history and present status point us the way to a rational forest policy. Although there had been royal hunting forests for 700 years previous, yet in 1870 the state owned but 1,053,000 acres of forest of all types. By purchase and other means, this area was increased to 15,475,000 acres in 1922; of which Table LVI, by Professor Tor Jonson, deals only with the productive acreage.

This table shows the extreme conservative character of Swedish state forestry, but its salient feature is the demonstration that forestry can pay its way, even while the growing stock is being built up and permanent improvement works executed. The extensive areas in the cold north have some virgin growth yet which is being steadily cut out because of decadence. These areas are incapable of very high volume production and tend to keep averages for the whole country very low; yet the net income of fifty-nine cents per acre per year is considerable on the total acreage of 9,500,000. These forests showed an income a little above the average during the War years, but times were hard and incomes below normal, just previous to and after the War. It was also difficult to get labor during some of the years of high prices, and the volume cut on many Swedish state forests during the period was actually below normal; so the above figures are nearly representative. They show a capital value at 5% of $112,000,000; in addition they have an inestimably greater value as pleasure and recreation grounds for the people, as a guarantee of economic stability and as protectors of the water-supply and streams which supply the power that makes Sweden great out of all proportions to her meager population of 6,000,000 souls.

TABLE LVI.—ECONOMIC SUMMARY OF SWEDISH STATE FORESTS
Average per Acre per Year; 1911–20 inclusive.

(Conversions based on the dollar = 3.75 kronor and hectare = 2.5 acres.)

	Cut		Gross Income		Expenses Lumbering, Transport and Supervision		Taxes	
	Cu. ft.	% of Whole	$	% of Whole	$	% of All	$	% of All
1—Upper Norrland	11	55	.51	42.1	.08	48.9	.01	7.6
2—Lower Norrland and Dalarne	25	26.4	1.60	28.6	.26	49.6	.04	7.3
3—Middle and South Sweden	28	18.6	2.55	28.3	.57	47.7	.10	8.4
Averages and Totals	15	100	.90	100	.15	48.5	.02	7.8

EXPENSES

	Silviculture and Protection		Drainage		Roads		Salaries and Fees		Miscellaneous		Totals	
	$	% of All	$	% of All	$	% of All	$	% of All	$	% of All	$	% of All
1—		2.		2.4	.01	3.4	.04	28.2	.01	7.6	.16	36.5
2—	.02	3.7	.02	3.3	.01	2.3	.10	20.4	.07	13.5	.52	26.
3—	.06	5.	.01	1.	.03	2.6	.24	19.8	.19	15.4	1.20	37.5
	.01	4.7	.01	2.2	.01	2.9	.07	22.9	.04	12.	.31	100

NET INCOME

	$	% of Gross	% of Whole
1—	.35	69.4	46.
2—	1.08	67.8	30.2
3—	1.35	52.6	23.8
	.59	64.7	100

Note:—As expenses and incomes are rounded off to the nearest cent, they do not agree with the percentage values.

The keynote in management of the state forests is sustained yield. Future well-being of the forest is never sacrificed for present profit. In this last principle we find probably the chief difference between government and private forestry. Sustained yield is the objective of most larger private forest owners, especially of the corporations engaged in the wood-using industries, yet it is not human nature to forego present advantages, and very often ideals as to the future must give way to expedients of the moment.

The importance of state owned lands, in particular forests, is considerable from a fiscal viewpoint; as can be seen in Tables LVII and LVIII, by Fredenberg [15–1927–81]. In these data two-thirds of the general cost of the Domain Department (" Domänstyrelsen ") is charged against administration of the state owned farm and forest land, while the other third is referred to law enforcement, coöperation, educational and advisory or other activities not even remotely connected with administration of these lands. All expenses and incomes were carefully checked, and the data give an excellent picture of what the state forests mean in a direct monetary way to the Swedish people. The table takes full cognizance of change in area and value of the State Forests in keeping with purchases and sales of land, as well as the rise in general prices.

It is natural for taxpayers to seek relief from their burdens, and it is not uncommon in Sweden to hear the complaint that the state forests are not managed in an aggressive business-like way. It is intimated that they should yield at least double their present net return. These charges do not appear worth consideration in the light of the data in Table LVII. In fact, an average income in excess of 6%, over a period of fifteen years, is certainly praiseworthy. It will also be noted that the state owned farm lands are a quite constant drag on the level of income maintained by the forests. The average for the farm lands is about 2.3%, and only in 1921 did they yield better than the forests.

Even when coupled with the draw-back of these farm lands, the forests take quite creditable standing when compared as to returns with the yields of other revenue-earning departments of the Swedish government. In Table LVIII are found both absolute and relative data showing operating profits of several important government departments.

No adjustments are made of expenditures by the Domain Department, hence figures for net incomes do not at all agree with the more exact ones in Table LVII. The facts in Table LVIII may or may not give comfort to advocates and opponents of government owned utilities, yet they proclaim that the State Domains turned over as much net revenue to the treasury during the period 1915–1921 as all the other four government departments combined.

It may be stated in passing that the state and municipally owned public utilities in Sweden are usually models of efficiency and as well managed as any we have in America under a similar set of conditions. Practically without exception, they surpass in service and economy similar privately owned and operated enterprises in Sweden. The low returns from all these government activities can be charged to two causes: (1) Necessity of large-scale improvement and modernizing or extension work. Capital investments absorbed much of

TABLE LVII.—Incomes from Swedish State Domains

Yrs.	Items	Gross Incomes	Expenses	Net Incomes	Valuation of the Property†	% of Income
1909	State Forests	$2,682,784	$ 918,387	$1,764,397	$26,648,847	
	State Farm Lands	503,747	61,546	442,201	16,229,303	
	Dept. Overhead		35,646			
	Total	$3,186,531	1,015,579	2,170,952	42,878,150	5.1
1910	State Forests	3,433,443	951,753	2,481,690	27,047,472	
	State Farm Lands	494,070	61,546	432,524	16,229,303	
	Dept. Overhead		35,079			
	Total	$3,927,513	1,048,378	2,879,135	43,276,775	6.6
1911	State Forests	3,352,608	1,091,187	2,261,421	27,258,081	
	State Farm Lands	474,033	61,546	412,487	15,990,649	
	Dept. Overhead		35,855			
	Total	$3,826,641	1,188,588	2,638,053	43,248,730	6.1
1912	State Forests	3,662,202	1,246,657	2,415,545	34,276,074	
	State Farm Lands	487,577	61,546	426,031	16,646,311	
	Dept. Overhead		33,371			
	Total	$4,149,779	1,341,574	2,808,205	50,922,385	5.5
1913	State Forests	4,482,990	1,519,542	3,323,448	34,572,357	
	State Farm Lands	479,738	53,279	426,459	16,352,636	
	Dept. Overhead		36,844			
	Total	$5,322,728	1,609,665	4,253,063	50,924,993	7.3
1914	State Forests	4,848,871	1,795,046	3,053,825	35,335,029	
	State Farm Lands	438,816	45,720	393,096	16,012,340	
	Dept. Overhead		35,841			
	Total	$5,287,687	1,876,607	3,411,080	51,347,369	6.6
1909 to 1914 Averages		$4,283,118	1,346,732	2,936,385	47,099,666	6.2

TABLE LVII.—INCOMES FROM SWEDISH STATE DOMAINS *(Continued)*

Yrs.	Items	Gross Incomes	Expenses	Net Incomes	Valuation of the Property†	% of Income
1915	State Forests	$7,060,030	$1,948,304	$5,111,726	$44,532,958	
	State Farm Lands	460,686	42,031	418,655	16,820,407	
	Dept. Overhead		36,834			
	Total	$7,520,716	2,027,169	5,493,547	61,353,365	9.0
1916	State Forests	9,227,998	2,416,225	6,811,773	44,881,425	
	State Farm Lands	476,625	41,576	435,039	16,362,473	
	Dept. Overhead		41,981			
	Total	$9,704,623	2,499,782	7,204,841	61,243,898	11.8
1917	State Forests	10,298,840	3,906,850	6,391,990	45,720,800	
	State Farm Lands	483,113	63,828	419,285	16,470,208	
	Dept. Overhead		50,189			
	Total	$10,781,953	4,020,867	6,761,086	61,191,008	10.0
1918	State Forests	14,490,234	5,023,346	9,466,888	45,720,800	
	State Farm Lands	481,233	58,165	423,068	16,470,208	
	Dept. Overhead		75,638			
	Total	$14,971,467	5,157,149	9,814,318	62,191,008	15.8
1919	State Forests	13,906,891	5,778,092	8,128,799	45,810,000	
	State Farm Lands	521,502	80,580	440,922	16,471,000	
	Dept. Overhead		105,940			
	Total	$14,428,393	5,964,612	8,463,781	62,281,000	13.6
1920	State Forests	13,691,518	6,872,542	6,818,976	82,049,387	
	State Farm Lands	521,093	78,913	442,180	23,602,345	
	Dept. Overhead		160,955			
	Total	$14,212,611	7,112,410	7,100,201	105,651,732	6.7

TABLE LVII.—INCOMES FROM SWEDISH STATE DOMAINS *(Continued)*

Yrs.	Items	Gross Incomes	Expenses	Net Incomes	Valuation of the Property	% of Income
1921	State Forests	5,638,938	7,189,194	1,550,256	82,186,550	
	*Uncollectible Bills		693,820			
	State Farm Lands	513,168	94,702	418,466	21,630,290	
	Dept. Overhead		174,548			
	Total	$6,152,106	8,152,264	2,000,158	103,816,840	1.9
1922	State Forests	7,452,009	5,039,118	2,412,891	82,781,743	
	Uncollectible Bills		60,700			
	State Farm Lands	543,710	135,216	408,484	22,566,000	
	Dept. Overhead		159,242			
	Total	$7,995,719	5,384,276	2,601,443	105,347,743	2.5
1923	State Forests	7,648,610	4,649,218	2,999,392	78,853,267	
	*Bad Bills		180,430			
	State Farm Lands	547,431	133,403	414,028	24,311,781	
	Dept. Overhead		152,054			
	Total	$8,196,041	5,115,105	3,080,936	103,165,048	3.0
1924	State Forests	7,029,497	5,310,057	1,719,440	78,668,552	
	Bad Bills		44,764			
	State Farm Lands	552,475	134,413	418,062	24,760,708	
	Dept. Overhead		149,164			
	Total	$7,581,972	5,638,398	1,943,574	103,429,260	1.9
1915 to 1924 Averages		10,164,560	5,108,203	5,056,357	83,067,228	6.1
1909 to 1924 Averages		$7,952,769	3,697,651	4,255,118	69,579,417	6.1

*Uncollectible or bad bills are not a net loss to the State. In practically every instance the material purchased and not paid for was forfeited to the state and likely appears in sales of later years.

†The property valuation taken from assessments and sales. It is conservatively low in all probability.

TABLE LVIII.—INCOMES FROM PUBLIC SERVICE DEPARTMENTS OF THE SWEDISH GOVERNMENT

Years	Post Office	Telegraph and Telephone	State Railways	Water Power Development	State Domains
Periodic and Average Annual Net Incomes					
1915–1918	$6,046,009	$12,222,462	$235,874	$5,331,631	$32,323,890
1919–1921	1,789,088	8,164,506	6,898,527	5,049,952	13,287,889
Totals	7,835,097	20,386,968	7,134,401	10,381,583	45,611,779
1922	4,107,570	6,900,863	6,505,809	2,205,254	1,606,975*
1923	4,333,951	6,059,908	9,155,217	2,431,821	2,892,186
Net Incomes in % of Capital					
1912–1915	35.16%	9.28%	3.75%	2.4 %	5.45*
1916–1920	14.92	6.27	−.24	3.73	8.21
1919	5.71	.52	−1.21	3.52	6.73
1920	−22.47	5.38	3.04	3.09	6.05
1921	50.55	8.92	.7	2.4	−1.3
1922	53.33	11.41	2.36	2.9	1.32
1923	46.98	9.47	3.37	3.1	2.45

*Data from Swedish Statistical Yearbook for 1924.

the expenditures since 1914 and were largely charged against incomes. (2) Since 1918 there has been much idle labor in Sweden. The Socialist government policy of giving employment on public works during such times of slack industrial demand has largely prevailed. This labor has seldom been very efficient, and has often been expended on improvements that yield low returns financially,—at least for the time being.

The business management of the state forests has undoubtedly been more effective and silviculture better during the period 1920–25 than ever before, even if the rates of income do not seem to bear this out. The great wonder lies in the existence of any net income at all when one investigates the data on rising expenses in Table LIX and contrasts the cutting.

The total increase in expenditures on the above major features of management has been 383%, which stands at marked contrast to the very conservative higher cut. Even during the war years the volume cut was only about a 50% increase on the 1909–1910 average.

FOREST TAXATION

The increase in taxation has been the heavy item that burdened forestry during the World War and later times, as is seen in the table of expenditures. Yet there is no special outcry for tax relief on the part of forest owners. High taxes are general and act as a terrific brake upon the wheels of progress in every line. Forest properties are usually organized so as to show a sustained yield, hence no special pleading for delayed taxes has met popular approval, altho one of the taxes paid is a yield tax and another is on incomes, and hence about the same thing.

The Swedish tax system is quite complicated. It reminds one of " wheels inside of wheels." Taxes are numerous and are sometimes laid by one governmental unit upon another; so it is literally true that taxes are laid on taxes. They are, as a rule, all inclusive in application as to every class of owner. The nationally owned forests are subject to all the local levies that beset the private individual. They also pay an income tax to support the central government, altho the total net revenues would finally reach the royal treasury anyhow. Such taxation has some disadvantages, *e. g.*, it is very needful that national forest officers watch and check up local tax assessments in order that unjust burdens be not imposed on the nation's property while similar private forests escape lightly [15–93]. It is quite likely that the government owned lands and forests are in general assessed somewhat higher for tax purposes than are those owned by local citizens. Yet with this tendency of one governmental unit to overreach another, and in spite of the extra accounting required, there is still an advantage in having all similar business enterprises, regardless of ownership, conducting their affairs on the same plane and thus permitting a direct comparison of results. For this reason, the Domain Department pays postage and rent for its office quarters in an old government building in Stockholm [15–106] and has

TABLE LIX.—Average Annual Expenditures and Cut in Management of Swedish State Forests

Period	Lumbering Transporation and Manufacture	Seeding Planting and Assistance to N. S. R.	Roads and Drainage	Building	Taxes and Fees	Wages Salaries and Travel	Volume of Cut (1000 cu. ft.)
1909–1911	$ 225,732	$ 59,608	$ 72,402	81,363	$120,918	327,000	105,713
1922–1924	1,406,462	172,597	399,743	367,826	876,380	1,057,008	138,402
Increase in % between Periods	523%	190%	452%	352%	625%	305%	31%

actually now no special privileges worthy of mention, altho earlier this was not the case.

Taxation in Sweden is not a fixt quantity either. Revisions, usually upward, have not been infrequent. Yet complaints seem rather exceptional and capital does not hesitate to go into forestry, chiefly because it is in most cases an organized business under high grade technical direction, with every effort being made to get some net income from every forest property so that taxes can be met when they fall due. When we begin to get this viewpoint in America, as foresters and forest owners, the tax problem will largely solve itself. It is in the main only a bugaboo, anyhow; originated by holders of cheaply, and at times dishonestly acquired virgin stumpage, who hope to hold this for huge unearned increments as society brings better transportation to their property and bids up prices for its products.

The " Single-tax " principles promulgated by Henry George seem to dominate the basic forest taxation system in Sweden. Assessments are made by local officials at the direction and according to instructions from the central government. All taxes may be based on this one assessment, but other alternatives may be chosen by the owner in some instances.

There exist three taxes or groups of taxes that bear on forest property: (1) National income tax. This is paid on actual incomes or increment in value of a property. In the absence of an income declaration by the owner or other responsible party, it is assumed that *the income is 6% of the assessed value,* unless reasons are at hand to suggest it is greater. The amount of the actual tax paid to the central government on the forest income is highly variable, depending upon the graduation of progressive schedules and the incidence of exemptions. (2) Annual local taxes total from five to ten mills on the assessed value of the forest, and are usually collected in whole or part on an income basis. (3) The " Skogs-accis " or severance tax of 2% on the net value of stumpage cut is paid into a fund for use of the local government units. Whenever cutting on a property exceeds a net stumpage value of $40.00 per year, 1.3% of that value is paid or set aside for the use and support of the provincial Forest Protection Commission. This " Forest Conservation Tax " is separate and distinct from the " Skogs-accis " [26–121]. At any rate, the severance tax is the least onerous portion by far of the tripartite tax burden. Even if over 3% of the net yield be taken, this on a 6% productive basis would amount for the average year to only a 1.8 mill tax as compared to the total for the national and other local taxes, which often exceed a thirty mill levy on the assessed value [41–234]. It is the present tendency of forest owners and economists to advocate an increased use of severance taxes with abandonment of direct property taxes and income taxes where the latter are based on growing stock increment primarily instead of actual monetary income. It has also been advocated that land and the growing stock on it be separately taxed, with payment deferred on the growing stock until it has attained approximate maturity. This type of tax reform has been enacted into law by some American states, but has not yielded the benefits hoped for. It is a practical and logical step in the development of Swedish forest taxation, as the present law puts separate values on the land and growing stock when assessment is made. The evils to be corrected are identical with those in America,—eliminating repeated taxation on the growing stock and relieving the burden of heavy annual payments that fall on the fictitious or latent income of a forest owner whose property is largely limited to areas of middle-aged and younger stands [1–342].

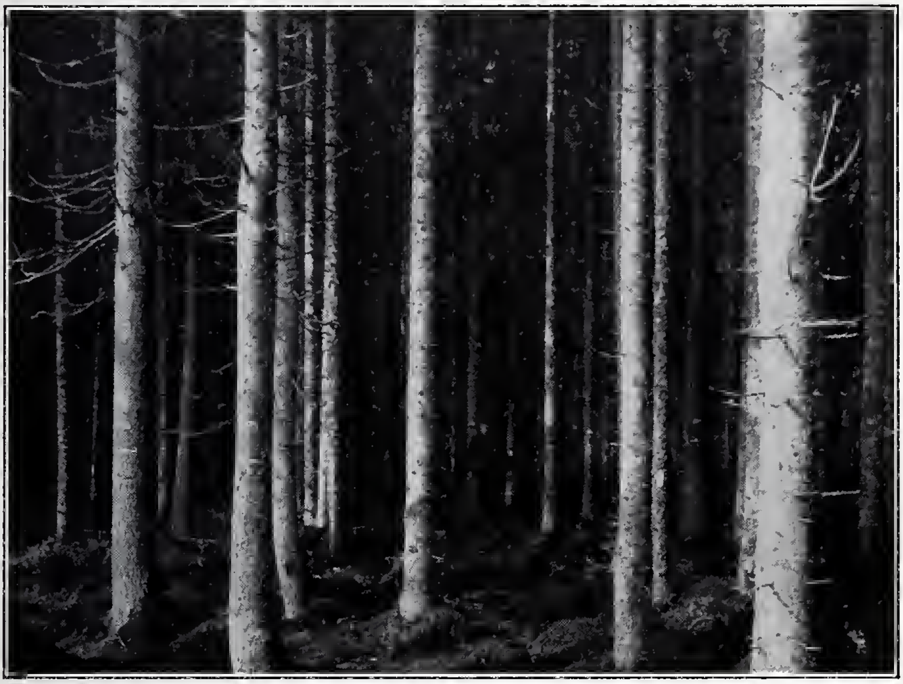

Fig. 7.—Pure Stand of Norway Spruce; a Forest Type Met Occasionally in Sweden.

Pure stands of spruce are often very high in production, but they undoubtedly tend to soil deterioration. This stand has a luxuriant soil cover of mosses. Planted spruce stands in South Sweden usually show a heavy needle cover without the sign of a green plant present on the forest floor.

An assessment of forest property is made every five years, falling most recently in 1922 and 1927. The methods are quite unique and show a striking combination of science, compromise and expediency. The essential underlying principle for determining the soil value is the Single-tax method. It has worked well and met with general favor. The procedure for valuation of the growing stock is the weakest and worst feature of the assessment. Forestry science has been brought to the fore in this great nation-wide valuation work.

The first step in the assessment is to determine the site quality of the property as to the whole, or what area there may be of each quality. This, as well as most other phases of the work, is made quite simple by tables prepared by trained foresters. In this instance, height on age of dominant trees, on or near the property in question, permit its site classification. The normal yield is then used to calculate the possible annual net yield per hectare (2.471 acres) under sustained yield management. In this calculation for the 1922 work the average stumpage price of forest products for 1912–1919 was used. In this way a normal income for the whole forest property is worked out, from which 25% is deducted arbitrarily as being needful for administration, protection and taxes. The remaining 75% of the normal stumpage income is capitalized at 6% to get the value of the forest soil and normal growing stock. The soil value is then fixed at 18% of this figure, while the other 82% is the value of a normal growing stock. Since few estates show normal forest conditions, the value of the growing stock is adjusted approximately in keeping with actual stocking. If the stock is above or below normal, the assessment is set above or below the normal value by whatever percentage of discrepancy there may exist. The actual assessment may be most clearly explained by use of an example:

A property of 1,000 acres is quite uniform thruout and supports thrifty stands of pine in polewood and younger stages of growth for the most part. The site quality is between II and III of the German scale and should show a normal net annual increment of 50 cu. ft. of wood per acre. Using the tables based on normal rotation yields with proper proportions of high grade timber and lower grade products it is seen that 50 cu. ft. of wood per acre means a net money yield at prices recently prevailing of 96 cents per year. When 25% is deducted for other expenses than utilization, 72 cents remain to be capitalized at 6%. This gives a normal value for land and forest of $12.00. The land value from an actual productive forestry standpoint is fixed at 18% of this, or $2.16. Hence the value of a normal growing stock would be $9.84. In this case, however, the stands are all young and the actual volume of the stock is only 80% of what is normal for 1,000 acres of site II and III pine land, so it is assessed 80% of $9.84 per acre, or $7.87. The final assessment for the property will therefore be 1,000 x $2.16, or $2,160 for the land, and 1,000 x $7.87, or $7,870 for the actual growing stock, making a total of $10,030 for the land and timber as it stands.

The adjustment of growing stock values by the local assessment officials, as before stated, is the weak feature of this Swedish tax-system. It can be made very accurately and honestly for all properties that are under working plans and have had occasional careful stock takings and increment studies. This is true of nearly all public forests and of quite a few larger privately owned ones. These properties serve as models in most localities with which other forest tracts can be compared and their stock assessed relatively closely. It is naturally not economic to run a stock survey for purpose of tax assessment alone.

It has been proposed that taxation of growing stock be discontinued and replaced by heavier rates on land alone or greater levies on net yields, funding the latter and spending only a conservative portion in any one year, so as to render public business independent of fluctuations in trade price levels and activity of the axe.

The use of 6% in capitalizing net incomes for derivation of the normal forest value has been criticized. It does seem too high and will likely be replaced by a rate of 5%, which will automatically raise all assessed values for land and forest growth 20%. This would probably be desirable, if the growing stock were at the same time relieved from taxation.

Most active in the field of forest tax reform in Sweden is Prof. Tor Jonson, Rektor of the Royal College of Forestry. In 1925, Professor Jonson summarized the tax burden usually found. The figures in Tables LX and LXI give a concrete statement of the actual payments for local and national purposes. Only the severance taxes are excluded from the data in these summaries.

TABLE LX.—FOREST TAXATION AND ASSESSED VALUES
(Summary of Local Taxes only, excluding Severance Levies)

	Forest	Site	Qualities
	I	II	III
Average Yield per Acre per Yr. (cu. ft.)	57	36	21
Average Stumpage Values ($ per cu. ft.)	$.045 to .076	$.038 to .06	$.023 to .038
Assessed Soil Values—Range ($ per A.)	$5.40 to 9.72	$2.70 to 5.40	$1.08 to 2.70
Assessed Soil Values—Average ($ per A.)	7.56	4.32	1.62
Assessed Growing Stock Values—Range ($ per A.)	21.60 to 43.20	10.80 to 21.60	5.40 to 10.80
Assessed Growing Stock, Values—Average ($ per A.)	32.40	16.20	6.48
Annual Taxes—Range ($ per A.)	.11 to .27	.054 to .135	.027 to .081

The data in Table LX show the actual national taxes paid on several crown forests. Private owners of similar lands with same management as to felling budget might pay a slightly lower tax, due to exemptions, if their acreage were small. Large properties, whose owners pay under the progressive schedules, might bear somewhat higher burdens.

From the tables of actual taxes paid, it is seen that 20 to 30 cents per acre is not an unusual total tax for Swedish forest lands of medium productive capacity. An additional 3.3% of the stumpage value harvested must be paid as a severance tax. These taxes are paid on lands that yield, *under normal forest conditions,* less than 40 cu. ft. of coniferous wood per acre and year. When the average taxation of forests in America, especially for second growth stands, or what would roughly average as being equivalent to a normal gradation of age classes, is considered, it is apparent that our taxes are lower than in Sweden. Moreover, this is true on lands that will yield double as high a rate of increment as the Swedish areas in question. Our long growing season and wealth of valuable species give us advantages that more than compensate for more favorable labor and transportation conditions in Scandinavia. Increase of population, with invention and general progress, will tend to equalize such price advantages as forestry may at present possess in Sweden. Even with present market conditions, over large regions of the eastern U. S. A. and Canada the opportunity and certainty of financial satisfaction from good rational forestry is as good or better than in Sweden, Norway or Finland.

TABLE LXI.—Taxation of Crown Forests by the Central Government

Name and Location of Forest	Assessed Value Soil and Growing Stock ($ per acre)	1924 Taxes ($ per acre)
Hamra Crown Forest,—Central	$14.58	$.151
Bispgarden School Forest,—North Central	15.34	.094
Bräcke Forest,—Central	20.52	.348
Frostvikens Forest,—Lower Norrland, High Mtn. Areas	8.64	.068
Omberg,—South (Cultured and Accessible)	52.16	.387

ADMINISTRATION AND PROTECTION COSTS

This phase of forest business in Sweden has been touched upon incidentally heretofore. If the above discussion on forest taxations is studied and data in the tables analyzed, it will be seen that ten to fifteen cents per acre per year have been allowed for administration and similar charges after payment of taxes. Expenditures are naturally quite variable. The state and corporations have spent most liberally in protecting and bettering their forests. During recent years, numerous large corporations owning forest property have far surpassed the government as to intensity of forest management. Tables LXII and LXIII give direct data comparing forestry by state and corporate owners in North and Central Sweden. They also emphasize the extent of forest improvement work in that region and give certain promise of very much greater yields from the forests of North Sweden in the future. The protection work is directed mostly against grazing and natural disadvantages, such as excessive moisture and development of adverse heath vegetation and resultant raw humus. Forest fires are rare, but occasional years show rather serious local losses. During the summer of 1927, fires were unusually numerous and destructive. Badly burnt areas are usually restored promptly to productivity by seeding or planting.

When the total expenses of state and corporate forestry work in Table LXII are compared, it is found that twenty-six representative

TABLE LXII.—FOREST PROTECTION, SILVICULTURE AND ADMINISTRATION ON STATE AND CORPORATE OWNED FORESTS IN NORRLAND AND DALARNE. (AVERAGES PER YEAR,—1911 TO 1920)

Owners	Areas Owned		New Drainage		Cleaning Old Drains and Streams		Seeding and Assistance Planting		New Plantings		Broadcast Slash Burning		Assistance Cutting		Fencing	
	Total	Productive	Length of Ditches and Streams (mi.)	Cost												
	(acres)	(acres)		$	mi.	$	acres	$	acres	$	acres	$	acres	$	mi.	$
20 Large Corporations	8,758,264	6,396,169	707.2	81,485	282.1	12,074	8,742	26,352	1,710	8,326	1,762	2,707	14,312	20,201	?	267
6 Small Corps.	179,345	151,139	5.0	1,232	1.	65	948	3,148	62	273	89	64	460	381		
Total for 26 Corps.	8,937,609	6,547,308	712.2	82,717	283.1	12,139	9,690	29,500	1,772	8,599	1,851	2,771	14,772	20,582		267
26 Corps. in % of State		77%	249%	157%	199%	335%	191%	109%	193%	99%				192%		10%
State Forests		8,466,036	284.7	52,558	142.1	3,612	5,063	26,950	919	8,649			?	10,731	29.5	2,763

forest owning private corporations have spent 149% of what the state spent in the same section of Sweden. Yet the state owned a considerable greater area of productive land, and in view of this it appears that the larger corporations on an area basis, are spending about twice as much in the administration and improvement of their forests as is the state. When percentages for work done and costs are inspected, it is seen that they are usually higher for the first than for the second item. This may be assumed to indicate that corporations get more done for their money than does the state, or are more efficient in the management and expenditure of capital in forestry. Such an assumption is scarcely justified by these incomplete data. To a visitor on the ground, an impression of thoroughness and care in activities on the state forests is universal. This is not always true of operations on corporate properties.

The actual expenditures on property discussed above is only 2½ cents per acre on corporate owned forests and 1¼ cents on state. Both figures are very low, but do not include charges for the overhead supervisory personnel. This item would probably double the total charge. It must also be remembered that the tables cited refer to the most inaccessible portion of Sweden where growth is slowest and forestry least intensive.

TABLE LXIII.—State and Corporate Forestry on a Comparative Basis
(Summarized from table LXII)

Work executed annually per average 2,500 acres (1,000 har.) of Productive Forest Land in North Sweden.

Nature of Activity	Amount and Cost of Work	
	State Forests	Corporate Forests
Ditching and Stream Cleaning	147 yds. for $15.22	470 yds. for $31.24
Direct Seeding	1.48 A. for $ 7.74	3.14 A. for $10.68
Planting	.27 A. for $ 2.40	.66 A. for $ 3.20
Broadcast Burning and Clearing Regeneration Areas	$ 3.20	$ 8.81
Fencing Regeneration Areas	.80	.11
Total Expenditures	$29.36	$54.04

Tables that precede give figures whereby it is possible to calculate the cost of administration on the state forests. These are not excessive for any part of the country, yet this is one feature of the forestry work of the central government in which it is hoped that future savings can be made or greater efficiency developed [15–101]. The scattered location of the lands of many crown forests is notable, and greatly increases the difficulty of boundary maintenance, protection against trespassing and conduct of improvement work, such as drainage, which must often be extensive in order to be efficient or economic, and in fact is at times impossible on a limited area where coöperation of adjacent owners cannot be secured.

The use of rectilinear boundaries also prevails in Sweden almost to the extent of being ridiculous, and is very inconvenient sometimes in localities with broken and steep topography. Many properties are very long and narrow in utter disregard to contour of the country.

It has been proposed to remedy the above conditions in so far as possible by exchanging land with private owners, accepting natural and convenient features for boundary lines wherever possible. Sale of certain inconveniently located and isolated forest lands, now owned by the state, has even been suggested and measures to this end offered in the Riksdag, but local opposition to selling the well managed and productive state forests has always developed and blocked this move for consolidation of the state forest holdings. The exchange of lands with large forest owning corporations is almost legally impossible in many cases, because most of these business organizations have issued mortgage bonds covering their lands, necessitating expense and trouble that may exceed all present advantages of exchange.

The crown forests that are most broken and scattered naturally lie in South and Central Sweden. Here the average number of separate blocks or continuous parcels of land in a forest or administrative unit (revir), is 25 to 50, but a good many exceed 50, and several consist of more than 100. In the most extreme instance, one forest includes 187 separate parcels of land. Even in lower Norrland there are forests with respectively 59, 64, and 75 separate areas to be policed and managed. In upper Norrland several forests include 20 or more parcels of land, but these are all, as a rule, rather large.

Much of the information presented heretofore in this chapter indicates and emphasizes the advantages gained in forestry by large organizations, whether private or public. This should be encouraging to us in America, where there still exists a considerable concentration of forest land ownership. Much of the land held by large holders is either present or potential forest land. Large holders are never notable for the development of the agricultural resources of a country. It would therefore be well and wise from the social and economic standpoint if our larger holders were compelled to practice rational forestry on all areas capable of supporting tree growth or of agricultural development, with the alternative always open that such lands must be farmed or grazed with an intensity of practice high enough to meet the approval of the county agricultural extension agents, or other officials designated by the land grant colleges in the several states. One of the greatest social evils today is the unduly high, speculative level of land prices that prevails nearly everywhere in America. Land should either be put to use growing a forest, or thrown on the market so that prices would fall enough to permit its purchase by the industrious, thrifty, young brawn and brain of the country who will put it to productive use and build thereon rural homes,—the supreme institution of humanity. For thirty years and more our government has tried to lead and coax the land owners of America into forestry and conservative use of the soil. The success achieved, so far as large holders is concerned, has certainly been dis-

TABLE LXIV.—INCREMENT OF SWEDISH FORESTS [45–61]

Regions	Productive Forest Area (acres)	Total Annual Increment		Deduction for Waste (%)	Net Annual Increment (cu. ft.)
		Cu. Ft. per A.	Cu. Ft.		
Upper Norrland	6,328,000	11.4	72,336,000	25%	54,251,000
Lower Norrland	9,495,000	17.9	169,537,000	25%	127,153,000
North Middle Sweden	20,898,000	28.6	597,077,000	15%	507,516,000
All South Sweden, except Halland, Blekinge and Skåne	17,199,000	35.7	614,252,000	8%	565,112,000
Halland, Blekinge and Skåne (= extreme South)	1,425,000	42.8	61,103,000	5%	58,048,000
Total All Sweden	55,345,000	27.3	1,514,305,000	13%	1,312,080,000

appointing. Would it not be well now to "kick" them in? As was the case in Sweden, there is every probability that in two or three decades those land owners, who went into forestry under compulsion, would be deeply grateful to society for the kick that sent them in.

INCREMENT DATA BY REGIONS

The values given in Table LXIV show how easily our forests may exceed in yield those of Sweden if we protect the young growth and permit it to make full use of the great climate advantages so liberally offered nearly everywhere in North American forest regions.

The increment table adjacent hereto is quoted from Oxholm and is subject to revision as more exact data become available. The figures given for area are considerably lower than those given by Jonson or more recent government estimates [22–297 and 26–116]. The increment, however, is considerably higher than Jonson claims when he sets the forest area at about 59,000,000 acres, producing 1,184,000,000 cu. ft. of wood per year. This is a mean annual increment per acre and year of only 20 cu. ft., compared to Oxholm's estimate of 27.3 gross and 23.7 cu. ft. net.

In humid regions of the U. S. A. there are few forest types, and almost no soil incapable of yielding 50 cu. ft. of wood per acre per year.

There are vast marsh and other waste areas in Sweden, however, that will ultimately be brought under forest. It is also quite feasible to increase considerably the yield of other forests. The mere operation of cutting away the extensive hyper-mature stands in Norrland and replacing them with young growth, that will show a good net increment, means a big step toward balancing the forestry felling budget of the Swedish nation. With this fact in mind, Professor Jonson states it is easily practicable to increase the total increment of the forests to 1,660,000,000 cu. ft. or more, at the same time reducing waste and eliminating many improper uses of wood, so the net yield available for domestic or export purposes can exceed ~~those~~ that of the present without overcutting.

The vast tracts of waste land listed in Table LXV include much that is capable of good forest production. The major portion is probably absolute ("impediment") wastes of glaciated rocky ridges and slopes, small lakes or bogs incapable of drainage on an economic basis. However, not less than 10,000,000 acres can be reclaimed profitably, and most of this is in public ownership or farm holdings, where it should receive exemplary attention. In fact, considerable work has been done by these owners, even if some of the preceding tables show corporations to have been more active in improving their properties. The provincial Forest Conservation Commissions are making good progress with drainage and forest planting on waste areas.

Oxholm [45–16] gives the water area of Sweden as 8.4% of the total area of 110,770,000 acres, or 9,336,000 acres. This is just about the same as the area under cultivation in 1916,—9,366,000 acres. Because of food scarcity an unusually large area was farmed during the World War. For 1916, it was estimated that 3,073,000 acres were in meadows and cleared pastures. This makes the area of forest and waste land total about 90,000,000 acres, and checks closely with the figures given by Jonson. The total area of bogs and swamps in Sweden was placed at 12,682,000 acres by Dr. Hj. V. Feilitzen in 1912. Of this total, about 4,500,000 acres lie in Central and South Sweden and extend a standing challenge to economists, drainage engineers, foresters and statesmen. It may come as a surprise to some readers when they note that less than 9% of the land area of Sweden is under cultivation, despite proximity to the teeming populations of Central and Southwest Europe, as well as undisturbed occupancy by its present people since the dawn of historic time, and probably almost since the retreat of the glacial ice.

TABLE LXV.—Forest and Waste Lands Compared as to Area and Ownership [22–270]

Type of Ownership and Management	Areas in Acres		Waste Areas in % of All
State Forests	Productive Forests	Waste Areas	
1. Crown Forests	8,449,963	3,984,769	31
2. Forests under Lease with Farms	196,111	49,637	21
3. Special Crown Lands	4,055	4,485	52.5
4. Sand Dune Plantations	2,592	227	8.1
5. State Share of Unsurveyed Areas	723,921	1,861,268	72
6. Forests whose Income is Allotted as Salaries of Civil Officers	10,484	5,167	33.
Totals	9,387,126	5,905,553	38.6
Other Public Forests			
1. Forests Assigned to Iron Industry	54,283	25,103	31.6
2. Reindeer Grazing Areas	407,376	2,191,896	84.2
3. Forests with Income Allotted to the Church	676,844	209,264	26.6
4. County Forests	197,161	56,457	22.2
5. Parish or Town Forests	1,026,275	457,180	30.8
6. City Forests	87,283	18,016	17.1
7. Local Shares of Unsurveyed Areas	341,270	10,421,230	96.7
8. Crown Lands Leased or Assigned for Special Purposes	637,496	734,727	53.7
Totals	3,427,788	14,113,873	80.6
Privately Owned Forests			
1. Corporate Owned	16,635,807	3,923,797	19.2
2. Large Estates	3,035,181	419,015	12.2
3. Farm Woodlots and Small Holdings	26,853,726	5,953,914	18.3
Totals	46,524,714	10,296,726	18.1
Grand Totals	59,339,628	30,316,152	33.5%

STATISTICS AND FACTS FROM A TYPICAL STATE FOREST [2-315]

Bjurfors Crown Forest, in Central Sweden, has a gross area of 16,000 acres, but 1,500 acres are cleared and rented out as farms and 3,000 acres are wastes—mostly peat bog, such as characterizes certain localities in the Lake States and northeastern U. S. A. It has been a " School forest " ever since acquisition by the state in 1894. In recent years it has been one of the summer practice camps of the Royal College of Forestry and the scene of considerable experimental and investigative work in forestry. Here are located a number of interesting plantings of forest trees exotic to Sweden, drainage, reproduction, forest nursery and increment projects.

The farm leases run for five-year periods with a priority right of renewal for the lesses or members of their immediate family. Rentals are relatively low, and each lease-holder agrees to work in the woods a certain number of days each year at a specified wage. This arrangement guarantees a labor force of good men, and serves to stabilize both forest and farm management.

The state originally paid $110,000, or about $6.80 per acre, for the property. It was then a run-down abandoned iron-furnace estate, similar in a way to several that have been purchased in Pennsylvania and managed as state forests since the collapse of " charcoal iron " operations there. The outstanding difference is in forest growing stock. In Pennsylvania this was predominantly hardwood, mostly oak and chestnut. In Sweden it was pine and spruce, with some birch.

In 1894 Bjurfors Forest had been badly overcut. Few stands exceeded thirty years in age, and many were irregular and incomplete. The local market, however, has always been good, as there is rail service to Stockholm only 100 miles distant, and several important industrial and iron manufacturing towns lie enroute.

The results of management are quite striking. During the first ten years about 2,000 cords of wood were cut annually. The yield then and now is mainly from thinnings. In the beginning only 25% of the volume cut was of size for saw timber or railroad ties. During the period of 1920–24, inclusive, the annual yield averaged 5,000 cords, of which 30% was saw logs. This rate of cutting can be continued indefinitely, and probably materially increased. Financial returns may be considered satisfactory. About 90% of the net income is derived from the forest and 10% from the leased farms. The latter are quite productive, but in net yield per acre fall below the less fertile areas under forest. In 1897 the whole property gave a net return of $2,400. By 1907 this had risen to $5,000, and the 1924 net yield was about $20,000. During one of the War years a maximum net income of $30,000 was attained.

Utilization operations call at present for thinning about 1,100 acres annually, which means using a ten-year cycle. Some twenty-four or thirty acres are cut clear each year. As the volume of larger growing stock increases, it will be possible to make final cuts on larger areas, ultimately clearcutting around 120 acres annually.

The present age-class conditions are as follows:

Age Class I (1– 20 yrs.) = 9%
" " II (21– 40 ") = 20
" " III (41– 60 ") = 25
" " IV (61– 80 ") = 35
" " V (81–100 ") = 10
" " VI (101–120 ") = 1
Total—100%

This age class résumé shows how normal status is being steadily approached.

Relatively little of the production of this forest is sold as stumpage. A good sawmill is located near the railroad station at Bjurfors, and this, with the desirability of familiarizing students with all possible utilization work, has led to the greatest possible refinement of the material harvested.

The forest school at Bjurfors is of ranger grade with a one-year course of instruction. The instructional work and administration of the forest is taken care of by a force of one Forester, one assistant or Junior Forester, three ordinary and two extra or special Rangers. Exclusive of such of the officers here listed, who are employed essentially in connection with the school, there is a total labor and supervisory personnel of about thirty men constantly employed on the forest, or the equivalent hereto. This signifies one man to about every 400 acres of productive forest. In addition, twelve to twenty men are employed in extra woods labor for three months in winter, when the mill pond must be stocked and charcoal, fuel wood, pit-props and other products sledded out of the woods.

TABLE LXVI.—MONETARY RETURNS FROM BJURFORS CROWN FOREST FOR TYPICAL YEARS

Year	Volume of Cut (cu. ft.)	Total Income	Total Expenses	Net Income	Net per Acre of Productive Forest Land
1897	122,913	$6,817	$4,441	$2,366	$.205
1905	168,830	6,747	4,927	1,820	.158
1910	384,845	17,036	12,187	4,849	.421
1915	552,930	46,022	20,004	26,018	2.258
1920	326,910	83,884	49,312	34,572	3.001

The sawmill is operated by steam. It is equipped with the usual Swedish gang-saw, a re-saw and an American type of planer. The annual cut is about 30,000 logs, yielding 825,000 board feet. The mill is run most steadily during spring and fall, occupying seventeen men. During winter and summer these men are for the most part engaged in felling, hauling, charcoaling, ditching and other forest improvement work.

The land drainage work on this forest has been especially successful. About 1,200 acres, or 10% of the total productive area, has been ditched. Most of this originally supported a scrubby and slow-growing forest, which has developed splendidly since the excess moisture has been led off [2–663 and 32–195 to 248].

Allison gives Table XLVI to show the good financial satisfaction achieved on this forest. It is notable that some years, especially prior to 1897, saw very low net returns, but that was only to be expected when the depleted state of the growing stock is recalled. Some years, on the other hand, show this forest returning a net revenue in excess of 25% on the original investment. The whole property has also appreciated much in value, due to the investment character of much of the annual expenditures. This means that there has been each year a large latent dividend from the property which cannot be appreciated from this table.

This example of the history and statistics of a Swedish forest gives a concrete idea of what forestry can do from a business standpoint. Forestry is " big business," and requires organization and enterprise, —two things for which America is famous. When we once get a deep and general grasp of what forestry means to America, we can and will succeed in this field even beyond the best examples to be cited from the Old World.

CHAPTER VII

NATURAL REGENERATION: USE, PROBLEMS AND SUCCESS IN SWEDISH FORESTRY

In every land where forests have abounded there is no question of the ability of the forest to perpetuate itself under natural conditions. Problems tend to arise about in proportion as human activity modifies the environment of the forest, and its essential component features. In discussing the general silvicultural condition prevalent in Europe, Dr. A. K. Cajander recently said in substance: " In North Europe reproduction of the forest is easy, in Central and Western Europe it is locally sometimes difficult, while in South Europe it is often all but impossible." Whether the greater obstacles confronting forestry in South Europe are, or are not, due to alterations wrought by man on the face of nature during the long centuries of historic occupancy, the writer is unable to say with authority, but the north lands are and have always been less densely populated and exhibit generally more natural conditions. In eastern North America, we might almost claim that the reverse of Dr. Cajander's statement is true. The continent has been most modified toward the north by man, and in the South reproduction of the forest is so easy that the aggressive yellow pines and sweet gum (*Liquidambar styraciflua*) often literally crowd mankind off the land.

It is recognized by all foresters that Sweden is well adapted to natural reforestation wherever the forest is reasonably well treated, but abuse may sometimes demand artificial seeding and planting. The extent to which seeding and planting are economically advisable is just as debatable in Sweden as anywhere else. Due to the proximity of Central Europe and the mania for planting that raged there all through the nineteenth century, the original forestry idea in Scandinavia was strongly inclined toward clearcutting and planting. This inclination persists even today, and has had among its influential advocates Prof. A. W. L. Wahlgren, and Lector J. A. Amilon; both authors of well written textbooks to guide the silvicultural practice of their country. As in America, it seems also that artificial establishment of the forest has a strong popular appeal which is sensed by trained practitioners and used consciously or intuitively as a means to entrench the science and profession in public favor. This fact is seen with reference to the provincial foresters, in charge of the very important work of the Forest Conservation Boards in each province. Very few of these men believe a planted forest, or one from spot sown seed, is as desirable as the growth that can be attained naturally, yet almost annually the reports by these foresters, covering work of their organizations, show an increased use of artificial methods in renewing the forest growth.

Probably to a greater extent than in any other land, direct seeding after soil preparation, usually in spots, prevails in Sweden. Climate, soil and biotic conditions all are favorable to successful stand establishment by this method and it avoids some of the most serious troubles that afflict stands established by planting, especially is this true concerning spruce, whose root system always suffers violence when stock more than two years old is planted. Some of the earliest direct seeding was accomplished by sowing or strewing cones over the area to be reforested [8–155]. The method has, however, become only a matter of historic interest, as it was somewhat uncertain of results when continuous wet weather prevented cones from opening. At best, it was wasteful of seed.

Clearcutting ("Trakthuggning") has always been, in one form or other, the chief regeneration system practiced in Sweden. Its popularity was at one time threatened by a lumberman's adaptation of selection forestry ("planlös Dimensionshuggning"), which consisted of applying a diameter limit cut on the old over-mature stands, often consisting of pine alone and without any young growth capable of development when the better big trees were removed. This kind of cutting, in the name of silviculture, so badly wrecked the forest, however, from standpoint of both appearance and increment, that it has been for years a stench and byword to forest owners and managers. Its failure caused a strong reaction in favor of clearcutting with natural or artificial regeneration, which persists to the present day and is the backbone of the opposition to the rising tide of sentiment and science supporting orderly selection forestry on a rational basis, which has swept everything before it in Switzerland, Norway and a large part of France.

One of the ablest foresters in Sweden, who has always been skeptical of some of the broad claims made by N. S. R. advocates, even if he admits the general soundness of their doctrines, has lately [59–8/1/1927–350] admitted that Sweden is now, in theory at least, irrevocably committed to silviculture on a natural basis, with strong tendencies toward acceptance of the principles of selection management for which District Forester Wallmo waged a valiant battle for thirty years and more.

The State forest service apparently leaves the decision as to regeneration methods largely up to local administrative officers. They predominantly seem to use clearcutting with scattered seed-trees, preparing these choice trees for their function wherever market and accessibility permit, by increment cuttings ("Frihuggning"). This system furthers the decay of litter on most sites and puts good growth on quality stems during the final years of a stand. It is primarily adapted to favoring pine, and that has been a major aim for two reasons: (1) the vast preponderance of public forest soils is not fertile or moist enough to support a thrifty growth of spruce; (2)

the latter tree in the past, before the paper industry sprang up, was much less valuable than pine.

In use of clearcutting, however, the state forester has always been quite watchful. If an area was so adverse that no advance growth could be secured, or if reproduction naturally came in slowly and threatened to be incomplete, seeding in spots, or possibly planting, would be resorted to. It is also noticeable that the advantages of selection forestry are courted by (1) leaving the greatest possible number of seed trees per acre, (2) by scattering the cutting areas to avoid large contiguous tracts of nearly or quite even age, and (3) by making the clearings as small as circumstances will allow.

The future is hard to foretell, but the selection idea will receive further impetus as accessibility of the forest and market prices improve. The work of Wagner, Eberhard, Von Kalitsch and Biolley in Central Europe has greatly impressed Swedish foresters. Climate may not be quite so favorable to selection as is the case in Norway and Switzerland, yet its advantages are so apparent to progressive students in the realm of forestry, that they will be continually striven for, and if unattainable for the time being, the next best thing is likely to be adopted, while the ultimate goal is constantly kept in sight. The tendency of the forests in the humid north to become "*drowned*" or water-logged when clearcutting is resorted to, and transpiration by vegetation becomes so greatly diminished, would seem to argue strongly for selection cutting, so this diminution in the transpirational power of the crop might be avoided. There is a counterbalancing effect that must be considered, however; *i. e.,* the accumulation of débris on the forest floor during a long period when the crown canopy is dense. This accumulation may become so heavy as to retain in its mass a very great proportion of the supply of certain essential fertility elements that the site possesses. Such an eventuality results naturally in decreased forest thrift. Clearcutting, by exposure to the sun, or by permitting use of fire, tends to free the bound up limiting elements and thus, at least temporarily, stimulates thrifty growth where other conditions do not inhibit it.

In the neighborhood of timber-line, or at the cold limit of pine, it has been noted that while this tree may only bear a good and abundant crop of seed at intervals of twenty years or more [59–9/1927–401] and cannot at all be depended upon to reproduce itself, yet vegetative growth is good, and no damage from cold occurs if the trees originate from seed collected near the northern limit of the range for the species. This has given rise to experiments in artificial reproduction and afforestation with pine in hope of raising the timber-line or making its inhospitable vicinity more productive. It is unlikely, however, that efforts in this direction will secure any general practical results. These sub-alpine or sub-arctic tracts impress the writer as being naturally better adapted to birch, spruce and larch than pine. In fact, Wibeck [59–9/1927–402) notes the ability of the spruce to increase its representation in these meager forest stands wherever it can get a foothold. In Norway the spruce has aroused considerable interest by its aggressiveness when introduced beyond its natural limits of occurrence [70–1927–266].

RESEARCH IN N. S. R. BY THE FOREST EXPERIMENT STATION AND COLLEGE OF FORESTRY

These institutions have made far more numerous studies in artificial regeneration of the forests than in natural, as is logical to expect, yet their work in both fields justifies the recommendation of natural methods wherever no extreme conditions require more expensive action.

Prof. Gunnar Schotte and Forester Eduard Wibeck have been the most noted figures in experimental work concerning N. S. R. Erik Lundh and Dr. Henrik Hesselman have contributed notable labors that incidentally set forth the advantages of natural over artificial regeneration work in the forest.

Wibeck [76] did some very good work on the seed-bearing of pine in Norrland and its germination. His studies demonstrated the infrequency of seeding. In fact, in certain localities it may almost never occur. In these same places spruce, however, does seed at times, and can also reproduce vegetatively by natural layering with considerable success. The seed of pine from its northern limit of growth and from alpine sites was found to exhibit delayed germination to an unexpected extent.

This delay in germination is a good argument for N. S. R., or direct seeding, in opposition to nursery practice and planting, as those seeds that grow a year after sowing are practically all lost in the seed beds, but in the field, especially under natural conditions, enjoy nearly or quite equal opportunity with early growing seeds. Wibeck [75–261] put in some telling blows for N. S. R., also, when he showed that the popular and cheap bar-dibble method of planting pine was a delusion and a snare, considered in the aspect of later thrift of the trees. It was demonstrated that the vast majority of pine trees planted by this method made slow growth, due to twisting and knotting of roots. They often even languished and died, or were weakened and predisposed to succumb when attacked by insects or fungi. Lindberg proved earlier, on the Bispgarden School Forest [59–1920], that pine transplants suffered very seriously from root deformation. He strongly advised, therefore, that untransplanted stock be used when pine is planted, and that all long roots be pruned off, so new ones will form and develop normally. This procedure is expensive and often causes loss of many plants when dry weather follows planting. Alternatives are using one-year-old plants or balled stock. Stock of one year old is so small it cannot well withstand drouth, frost-heaving or weed competition. Ball planting is rarely practicable in forestry. These studies also showed that puddling roots in mud so they cling together in a stringy state is undesirable. No investigation seems to have been made on the effect of planting in open holes made with a mattock, as is most customary in America. It has been observed here, however, that root deformation is rather common with this planting method, too, especially when trees are hastily set against the side of the hole with roots pressed roughly into a curved plane.

Under the method of dibble planting, prevalent in Sweden, it was found that with one-year stock, 50% to 66% of the trees developed abnormal root systems, and 20% were seriously enough crippled to cause death. When two-year stock was planted, about 67% developed root deformity, and 25% were seriously afflicted. For three-year seedlings, about 75% and 25% were the corresponding figures.

The most striking fact in this root trouble was its stimulus of stem growth during early life of the planted trees. Up to about fifteen years of age, trees with deformed roots led their normal associates in both diameter and height increment. The physiological reasons for this apparently lay in the constricting effect of abnormal root arrangement. The roots seemed to starve by degrees as tops became overdeveloped, due to monopolization of the food materials elaborated by the foliage. The long persistence of this rapid growth on the part of doomed trees may be a really serious danger where heavy early thinning is practiced, and the apparently superior trees that remain fall victims to wind and ice, drouth or insects. Wibeck suggests that the unsatisfactory appearance and lack of thrift in certain older pine plantations in North Sweden are due to the root trouble above described. He strongly advocates direct seeding in prepared spots. It is logical to consider every one of his points as good arguments in favor of N. S. R., altho controversy has raged over certain conclusions.

Professor Schotte [56–1923–305] made several weighty points for natural regeneration of pine, as did O. Eneroth also, in studies concerning use of seed for sowing and planting under climatic conditions widely divergent (colder in particular) from those of the locality of origin. Trees not only made very poor growth, as a rule, in regions with a climate foreign to that enjoyed by their ancestors for generations unnumbered, but they were very much inclined to disease and every form of natural physical injury. Snow shedding (*Phacidium infestans*) was especially vicious in its attack on trees originating from seed brought north from pleasanter climes. The cumbersome administrative machinery and provoking red tape recently invoked in Germany to guarantee immunity from use of ill-adapted pine seed, is sure to react favorably for N. S. R., since it emphasizes indirectly but most incisively the serious character of the error a land owner makes when he introduces pine of inferior quality and ill-adapted heredity into his forests [64–1926–381].

Prof. Schotte, in his careful study of N. S. R. in Norrland [53], showed the ready and easy regeneration that follows on areas protected from fire and overgrazing, even in that most adverse part of the country. He also settled the question of development possibility of the dwarfed spruce that are so common in Swedish forests. On sites favorable to this species such advance growth, even when most unpromising in appearance, can still recover from decades of suppression and make good trees as to both increment and quality of product. Stunted pine, much to the surprise of most foresters, showed an equal and quicker recovery when given optimum light conditions. Of course, this species will not withstand shade for long years, as does spruce; hence it occurs only where the canopy of the larger trees is thin, yet because of its ability to make rapid growth on even the poorest sites, pine is often to be preferred, and its recovery from suppression is very important to cheap and desirable N. S. R.

It was long maintained that these dwarfed and often quite old specimens ("*Marbuskar*") of pine and spruce possessed no future possibilities. It was generally advocated by disciples of the old German school of silviculture that all such advance growth be cut away or burnt up so as to permit securing a full and even new crop by artificial or natural methods. In regions with such economic conditions as prevail in Northwest Europe or the U. S. A. such a theory almost meant broadcast burning, and that means ever and always: (1) loss of five to ten years' growth in terms of the rotation length, because advance growth, with its quite extensive root systems already developed, is at least that much ahead of ungerminated seed or even transplants; (2) deterioration of soil as result of decreased organic content and evolution of unsatisfactory biotic conditions; (3) origin of pure or nearly pure stands with elimination of most plant or tree species whose litter has an anti-acid effect on soil reaction in humus development.

Instruction at the Royal College of Forestry, Stockholm, has mostly been along lines of practical applied silviculture [74 and 3]. It has been very thorough, but modeled somewhat too closely after older work in Central Europe. The criticism can be justly made against both Swedish and American instruction in the art of getting a new growth forest, that too much time and space is devoted to seeding and planting, while the more practical methods of regeneration with later treatment of stands and fundamental relationships between the forest and soil have been largely neglected.

SOIL AND MATURE CROP FEATURES

Professor Hesselman has published [19] a most thorogoing discussion on the subject of forest soils, with special reference to the humus in coniferous stands. This discussion summarizes several years of carefully planned and painstaking work. He shows most clearly that forest soils are a dynamic rather than static quantity from standpoint of forest thrift and productivity. Wherever the reaction of the soil electrolytically is being changed in the direction of greater acidity of its upper layers, the forest is deteriorating, but where the alteration in soil reaction, due to character of litter or silvicultural treatment, as a rule, is toward alkilinity, improved forest thrift and production can be noted. In short, the status of the soil as regards *Ph* (relative acidity) seems of little consequence to vegetation as contrasted with the evolutionary circumstances in this connection. For example, on soils of considerable lime content, forest humus tends to be but slightly acid, while on a mineral substratum low in lime it will be quite acid; yet on both of such sites by growing a mixt forest stand, with such species as birch, beech, elm, hazel, larch, aspens and alder present especially, or with periodic exposure of the forest floor to direct sunlight, it is possible to bring about a certain slow change in the upper soil strata in the direction of decreased acidity.

All the above facts are strong indices to proper silvicultural management of our forests. They point to the imperative necessity of intermixing a certain number of desirable hardwood trees, or species, with similar effect on the soil, thruout all stands of spruce, pine, fir and other such trees as tend to render the soil acid in reaction and unsatisfactory from a biological standpoint. Natural regeneration, especially under a system of selection cutting, is certainly indicated by these studies on the forest humus problem. Humus is truly the life of the forest, and work now being done in Sweden by Dr. Elias Melin, Prof. Hesselman, Dr. Olof Arrhenius and others may be of immeasurable value to forest production everywhere in the world [19, 35 and 4].

Silvicultural Systems,—Clearcutting (" Kalavverkning ")

The practice of clearcutting in Sweden has never meant what it does in America. Where in the past it was common to clear off a tract, this was rarely large in area. Very often fire followed or was used in clearing. Since the areas were nearly always small, abundant seed reached the soil from adjacent stands and regeneration was no problem at all; especially when it was very often true also that occasional wide-crowned limby trees with little lumber value were permitted to stand and would add to the seed considerably. When more recently lumbering became a big business proposition, the regeneration of such cleared areas by direct seeding in spots or rows has been very frequent. Clearcutting has been responsible for the origin of many excellent forest stands in Sweden. The usual result has been pure or nearly pure stands of pine. Cones of Scotch pine are far tardier in opening under North European climatic conditions than is the case where this tree has been introduced in the U. S. It shows some of the characteristics of a " fire pine " and doubtlessly often seeded up extensive areas after forest fires had killed trees with unopened persistent cones in their crowns. Seed in many such cones would not be injured, even when the brush and débris after lumbering were burnt broadcast, since they, as well as the small and heavy seeds, would tend to nestle down close to the cool and humid earth, where the effect of even quite a severe conflagration would be minimized. Unopened pine cones are very efficient non-conductors, and it is believed that evaporation from the cone scales and axis would protect the seed viability so long as they do not open. Such facts as these would amply explain the good stands of pine secured generally over all Sweden and Finland, where conditions were as described. The prevailing delayed germination, exhibited by pine seed from northern regions, would also be helpful to the species in such instances where slash was burnt a year or two after lumbering.

Strip clearcutting after approved German practice, as well as some recent efforts to follow the border ("Blendersaumschlag") felling principles of Wagner, have met with success; but, all in all, play quite a minor rôle [64–1915–570]. Such methods of N. S. R. as these are being considered and tried out experimentally by many progressive foresters and forest owners, because thereby it may be possible to avoid the heavy expense entailed by seed sowing or planting. The strongest tendency in recent Swedish N. S. R. has been toward the seed-tree method, often combined with some soil preparation to bare the mineral substratum or with direct seeding in rows or spots. Exposing the mineral soil has been found very helpful to N. S. R. in the Baltic lands. It comes, then, somewhat as a surprise to a forester traversing Europe, when he finds Swiss and French foresters often bitterly condemning removal of litter and baring the soil as aids to natural reproduction. It is probable, however, that both these apparently antagonistic schools of thought on this subject are right.

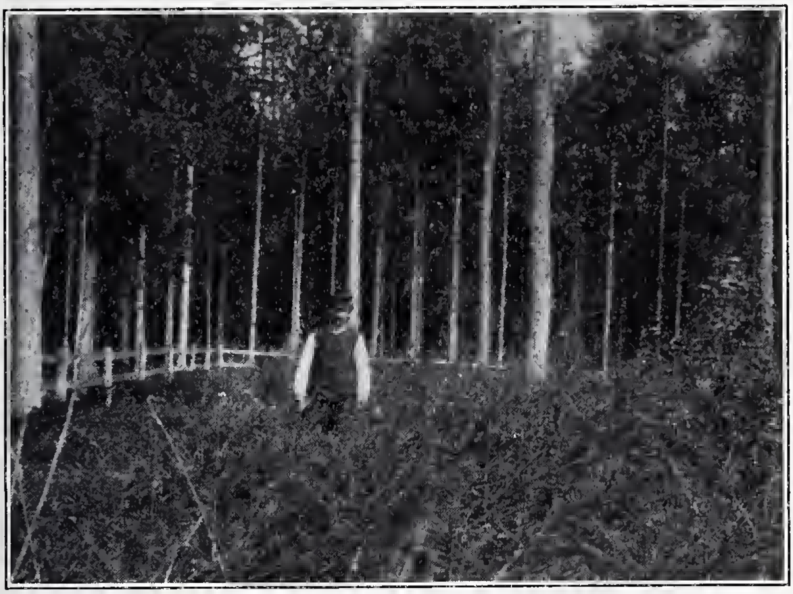

Fig. 8.—Reproduction of European Silver Fir in Central Sweden.

Group clear-cutting and baring the mineral soil in a seed-year results in very dense young growth.

In cool and moist regions, clearcutting and practices that bring about decomposition of litter and accumulated raw humus, are quite desirable. But where the climate is warmer and soils are well drained or calcareous in origin, no raw humus problem ever arises, and it must rather be the chief care of the forest manager to husband the organic matter in and upon the forest soil by every means possible.

THE SEED-TREE METHOD ("FRÖTRÄDSSTÄLLNING")

This system of N. S. R., in its effect on the site and early thrift of seedlings, differs but slightly from other clearcutting methods. It has been a logical transitional development on many forests where good conservative stand management has been introduced. Thinnings are applied more and more intensively until the grade of " light-cutting " or " free-cutting " is reached and reproduction becomes more or less established as advanced growth. Where such a volunteer new crop of rather irregular appearance is undesired and discouraged, the trees are still steadily developed into good seed producers with strong extensive root systems that guarantee wind resistance. The soil is also favorably modified by gradual exposure to the sun and offers tree seed a good receptive bed for germination and growth.

Swedish writers on silviculture, and practitioners, too, seem to confuse or combine clearcutting with scattered seed trees and the shelterwood compartment system. Due to the steady cutting in stands prior to operations with a final definite major aim at reproduction, it is easy to see how practical application of these two methods becomes just about identical. The writer would consider use of fire to remove débris by broadcast burning as the only real distinction between the two [74–304]. If fire is not used, except possibly to burn piled brush, the reproduction is more irregular or clumpy as characterizes shelterwoods. After broadcast burning, seedlings come in quite evenly, as a rule, which is an earmark of all clearcutting practice.

The number of seed trees left per acre has also some bearing in deciding the above question; since in shelterwood cutting the amount of shade must be sufficient to exert a certain protective influence on the seedlings in the new crop. In Sweden [3–479] the number of seed trees left is quite variable, but has tended to increase during recent years on forests where intensive methods prevail. About twelve trees per acre is considered a sparse stand for seeding purposes, yet if many more are allowed to remain for seed the shade case by their crowns is considerable. We should note, in passing, that spruce seed trees are rarely left, due to danger from wind and because this tree can usually be depended upon to come in gratuitously, if the site is suitable, and in fact is nearly always present as advance growth. Pine crowns are usually rather open and small in these boreal lands. It is not uncommon, therefore, to find twenty-five to forty seed trees per acre. Under such an application of this N. S. R. method, truly shelterwood conditions prevail on the forest floor.

SHELTERWOOD CUTTING

This method is seen from the foregoing to be actually rather frequently used in Sweden, even if the nomenclature of silviculture would lead one to think it nearly unknown. It has been very successful in reproducing beech, ash, and oak in extreme South Sweden and parts of Denmark.

Wahlgren [74–314] comments on the success of the two foregoing methods by stating that it is usually necessary to reinforce natural regeneration by artificial, if a full stand is desired. Whether this statement is to be taken at par is questionable. Foresters and land owners are often impatient and insist upon immediate results. Seeding in spots is commonly resorted to on many areas which nature would seed up fully if man would but wait until one or two full mast years materialized. In South and Central Sweden seedlings of larch and large transplants of spruce are sometimes used to reenforce natural growth. Use of European, Siberian and Japanese larch in this way has given excellent results in localities where soil fertility is favorable. These very rapid-growing conifers often take their place in considerable numbers in the upper crown canopy, they improve the soil and tend to prevent raw humus formation; while at the same time securing a degree of protection against their deadly enemy, larch canker, by virtue of sporadic distribution in stands of other species.

SELECTION FORESTRY ("BLÄDNING")

Only a few older examples of good practice along this line of forest management are to be found in Sweden. In Norway, on the other hand, it has almost attained the importance of a "National System" of forestry, and quite a few highly productive forests afford convincing and irrefutable evidence of the good results it can yield under wise supervision. In both countries the long practiced method of diameter limit cutting (timmerblädning) has led to such disappointing results, that a dark cloud long rested over selection cutting generally. In Sweden, the reaction against the selection principles was all the stronger because a crude and erroneous application of the idea was required by law on certain lands. In recent years the pendulum of forestry thought has begun to swing in the other direction again, however, and in spite of all the protests uttered by conservative advocates of artificial forest regeneration, selection felling, especially by rationally located groups, is becoming steadily more popular as its merits appear in sharper outline on the horizon of experience.

Swedish foresters have made some interesting improvements in application of group selection. It is not uncommon to see them concentrating the brush and débris along the north and east periphery of a group cutting. The soil there becomes quite highly heated and dries out early in spring, if no measures are taken to prevent this. When the soil is covered with brush rather thickly except for small bare spots, in these a sufficient number of vigorous seedlings will usually develop right up to the butts of standing trees.

Group selection forestry in Sweden is a very logical development, and is bound to become more and more important, wherever pine is the preferred forest tree, as management is intensified. Clearcutting was the original method used in reproducing such stands, but it was observed that the smaller the felling areas were made, the better the reproduction secured. The group selection system, therefore, suggested itself, but was at first rather generally rejected by forest managers because they thought it entailed too great expenses for roads and transportation. When, during the past ten or twenty years, the importance of thinnings in forest management became apparent, it was necessary in applying these that every stand be cut thru at intervals of four to ten years, hence the question was again raised: why not cut in groups with a cutting cycle of about eight years and get ideal regeneration, at the same time [3–494] doing such intermediate cutting as may be necessary.

Single tree selection felling is quite infrequent in Sweden, except where pulpwood is a desired product and soil fertility and moisture are favorable to spruce.

To summarize N. S. R. in Swedish forestry, it is safe to prophesy a bright future for the selection idea. This method has won adherents rapidly in the recent past, in spite of obstacles and misapprehensions. One of the greatest obstacles in some localities is the practice of general " range grazing." It is possible to fence limited clearcut regeneration areas, but selection demands for best results, fencing of the whole forest wherever considerable numbers of stock are running at large. Restricted grazing has been considered beneficial in some localities, because it helps to hold in check hardwood reproduction and growth to a far greater degree than it retards the conifers. As modern fence laws become universally adopted, selection cutting will certainly win further terrain.

TIMBER-LINE AND PROTECTION FOREST AREAS

As the limit of tree growth is approached when ascending from lower elevations, it becomes more and more difficult for the forest to maintain and reproduce itself. The timber-line has been gradually retreating from the mountain heights in Scandinavia for centuries. Some testimony contradictory to this statement can be found [70–1927–16, 448 and 500], but evidence to support it predominates and is irrefutable. It is not unusual to find the remnants of large pine trees far above the present upper limit of this species in the locality. The very appearance of the prevailing tree species (alpine white birch), as one approaches the bleak heights (fjällsträckor) where it, too, disappears, is sufficient to show it to be receding in defeat before the year-long and ceaseless centuries of assault from those pitiless allies, wind and cold. The total absence of thrifty young specimens of reproduction of any kind whatsoever impresses the forester as soon as he sees these alpine forests. Heath species of several kinds, but growing only a few inches in height at best, compete with mosses and lichens for possession of the soil, whose icy bosom never thaws to more than a few inches deep. Such sites are open, as a rule, and light is not a factor in limiting regrowth of trees.

Reindeer grazing by both wild and domestic herds are a factor tending to reduce the chances of the forest reproducing itself in some localities. The Lapps are quite nomadic in habit, and also destructive and thoughtless in their treatment of trees, even tho wood fuel is an imperative necessity. They range about from time to time over vast areas of this struggling timber-line forest and because of the exact balance of the factors concerned, probably often turn the decision against tree growth.

Yet in spite of some investigation of the boreal and alpine forests in Norway and Finland [70–9/1927–407 and 10–#4–192], much still remains to be learned concerning conditions, causes and effects at hand on these adverse sites. It has been known for some decades that reproduction by vegetative means is the rule. Seed is borne very rarely and conditions for germination are so poor that few plants indeed ever get a start this way. The slowness of seedling growth in face of the manifold dangers that beset small trees means almost certainly their extermination. The pine is, however, still entirely dependent upon seed for reproduction. Spruce spreads by seed when very infrequent favorable years result in their production. It also multiplies much more effectively by rooting of the characteristic long lower lateral branches. This tree alone seems to be gaining ground at the cold limit of its range, but these gains are slowly and painfully accumulated. The traveler in these inhospitable regions will find no more dreary and dismal scene than the old, dejected, wretched, ghastly, weird, lichen-hung spruce stands occasionally met near timber-line. The scientific world has only recently discovered that the birch commonly reproduces by root-suckers. It was long known that stool shoots and natural layering were important methods whereby the birch forest maintained itself in localities where snow and ice are nearly perpetual, but [70–1926] in Norway it was definitely demonstrated in 1925 that under adverse conditions, suckering from the long roots, which develop near the surface of the cold soil, may be most important to the reproduction of this tree.

All Scandinavia is deeply and closely dissected by streams that head in the mountain backbone separating Norway and Sweden. The forest follows each stream valley back into the high mountain plateau region, causing the timber-line to stretch a very crooked and long course as it divides the forest from the waste alpine spaces at higher elevation. It has been calculated that the timber-line in Norway alone is nearly 32,000 miles long. Sweden naturally has a shorter length, but the total for the whole peninsula cannot be less than 50,000 miles [70–1927–497]. On the basis that this gives, we can compute a more or less pronounced timber-line type of forest over an area of 32,000,000 acres, if the band where the type exists be only one mile wide on the average, which is probably very conservative. Of course, the width of the forest belt where the adverse character of the climate sets its stamp on the forest is extremely variable, dependent primarily upon steepness of slope. Some localities exhibit miles of nearly level plateau land or slopes where the gnarled and dwarf trees present typical timber-line aspects, elsewhere on the mountainsides one can see a quite sharp transition from fairly thrifty, altho small, growth, to the treeless areas above.

Haakon Lie has both truth and poetry in his sentiment: " The timber-line or protection forest region is the most glorious part of Norway; a land of battle. Here the fight is on to determine if mankind shall live in the valleys or not; whether the folks of the Northland shall retain their inheritance. It is as tho we saw our own people standing embattled under the northern lights in the bitter storms. The timber-line forest should be dear to us as our best ally and the symbol of our own hardy racial stock."

These struggling forests have been long appreciated by economists and statesmen, as well as foresters. If they be destroyed and the limit of tree growth is forced down it means not only the loss from scant productivity of the lands affected, but also that much greater areas of land lying below will deteriorate as to climatic and soil conditions; thus becoming less productive or suitable to human use. The facts outlined above are matters of common knowledge with intelligent people in Sweden, and were crystallized about the beginning of the century in the " Protection Forest Law " and " Lappmark Law," to prevent the abuse and denudation of these essential areas when under private ownership (See Chapter I). The portion of this forest under public ownership is classed under the caption, "Reindeer Grazing Alpine Forest," with a total area of 2,600,000 acres, whereof only about 400,000 acres are classed as productive [55–137]. All of these vast areas, both private and public, are ordained by law to be managed very conservatively under selection cutting principles. It is well known that these forests are utterly void of commercial value, but their economic import indirectly thru climatological factors, stream-flow, wild life support and preservation, popular recreation and sentimental appeal is considerable.

Cutting in this type of forest should be limited [74–372] to removal of hypermature trees that are surrounded by young growth or seriously injured by fungi or other enemies. Where conifers are intermixt with birch, the latter should be cut away so as to encourage seed bearing by the former. Such trees as show themselves to be heavy seeders, by presence of many old cones on their crowns, should be retained as long as possible, as is true also of such trees as protect groups of young growth against the biting north winds. These are the essential rules whereby Swedish foresters hope to hold and improve the living wall that defends their inhabited lands and productive forests against the cruel and deadly barrenness of the mountain wastes.

Only in these timber-line forests is it considered good silviculture to leave spruce seed trees. Elsewhere the species is not hardy enough to serve its purpose in this connection, but on the high mountains this tree is more vigorous than at lower elevations.

Raw humus formation and drowning of the forest are imminent dangers near timber-line. They indicate the desirability of piling or burning brush after cutting, group felling, drainage work and soil cultivation. However, these measures are naturally out of the question on areas that afford no hope of commercial returns.

The Forest Research Institute has been interested for some years in experimental work with exotic species as a means of stabilizing the timber-line or pushing it upward. Little progress has been made, however, due to the almost insurmountable difficulty of getting seed from suitable localities in the range of such trees as offer some promise. The following American species would be worthy of trial under the conditions that prevail: Black Spruce (*Picea mariana*), Englemann Spruce (*P. engelmannii*), Logepole Pine (*Pinus murrayana*), Black Hemlock (*Tsuga mertensiana*), Alpine Larch (*Larix lyalli*), and Alpine Fir (*Abies lasiocarpa*).

COPPICE AND MIXT REGENERATION

The climate of Sweden is not warm enough to encourage vigorous coppicing, if we respect the opinions of accepted authorities, to the effect that vigor in this connection for a given species varies by inverse ratio with latitude. Altho the foregoing topic recites the superiority and predominance of vegetative over seed regeneration in the boreal timber-line forests, it is not possible to find coppice stands in Sweden to disprove the general rule. The conifers and birch seed so well over most of the country that reproduction of the forest by sprouts has rarely been even thought of, and almost never attempted, if we exclude the prevalent pollarding practice seen nearly everywhere in South Sweden and occasionally on the island of Gottland; willows of several kinds and the Black Poplar (*Populus nigra*) being the usual sufferers. The aspen is a vigorous root-suckering species wherever it occurs, and is therefore considered a pest by foresters in some localities where it has no market or is worthless by reason of early heart rot. It is the rule under such conditions to cut out all aspen from forest stands five or ten years prior to regeneration. In this way the tree is eliminated from the succeeding stand, as its sprouts require considerable light for development.

Wahlgren [74–343] considers coppice management worthy of more attention than it now receives in Sweden. He not only recommends its adoption and systematic use in the alpine birch stands near timber-line, but also for all hardwood trees except beech, on incompletely drained marshes, lands subject to temporary overflow, lake and stream bank sites, and on steep slopes in agricultural localities. He cites the following height growth of coppice on quite poor soil in Uppland, Central Sweden, at the end of five years: Ash, 12.5 ft., birch, 16.4 ft., and pedunculate oak, 10.8 ft.

Coppice management was noted by the author on farms in Middle and South Sweden; alder, birch and ash being the species grown. Results appeared comparable to those attained in Belgium or the Rhineland of Germany. Some attempts were also being fostered by the match manufacturers to grow raw material of aspen in mixt root sucker and seedling stands. Success was not very confidently expected because of the decay that threatened the stand in early life and spread rapidly from tree to tree thru their flat and connected or grafted root-systems.

FOREST CONVERSION

In Sweden, as in all lands, forest stands change because of human activities. It is rather rare, however, to find species being intentionally replaced in the forest as part of the management scheme; except where the eliminated species has, for one reason or other, the character of a weed. Areas grown up to the common juniper and scattered birch are often seeded or planted up to pine, or pine and spruce in mixture. Stands where aspen has been a common or important species are not reproduced to that tree for fear of rot. Birch is generally discouraged to the advantage of conifers, unless fuel is the product desired,—when the reverse is true. Spruce seems to be gaining favor and ground in the forest. Yet these changes in stand composition are usually secured by natural methods and offer little of interest to the silviculturist.

In South Sweden, especially along the rocky reaches of the west coast, forest conversion has occurred on a considerable scale. It had its beginning in the abuse of the oak and beech forests that occupied these parts in Viking times. Shipbuilding, fuel needs, potash burning and grazing fires during the course of centuries exacted an unbearable toll from the natural forest growth, so that nearly barren heath tracts replaced splendid original forest of mast-bearing trees. During the last half of the past century much interest was aroused in the reforestation of these unproductive areas. The work has been well systematized and in general highly successful. Spruce has been the favorite tree, and many splendid young stands testify to the suitability of this region, with its humid winds, to the requirements of this rather exacting conifer. It should also be remarked, in passing, that larch failed here emphatically because of canker (*Dasyschyfa wilkommii*) ravages.

Swedish nature lovers lament bitterly the tendency of land owners in the South to establish monotonous pure spruce stands in place of the " noble leaf-trees " that once held sway. Yet from the standpoint of increment on a volume basis, the coniferous stands justify themselves completely. Even the state forests show the universal trend toward conifers. The nature lovers, however, may find unexpected allies to turn the final victory in their favor. Some of the large even-aged spruce stands have already suffered serious attacks from defoliating insects, (*Lyda piceæ* or *Cephalia signata*), the Spruce saw-fly having done the heaviest damage to date.

Swedish forest conversion by artificial means has been largely by direct action. Stands are clear cut and denuded so far as feasible; thereafter the desired species have been seeded in or planted, and successive assistance cuttings made to give the new crop a satisfactory start.

CLEANING AND FREEING YOUNG STANDS; ASSISTANCE CUTTING,—("RÖJNING")

Foresters in America generally lament the fact, or seem surprised when forest plantations require from one to three cleanings to guarantee their satisfactory establishment. This work is an important item in the program of European foresters wherever the business is on an intensive basis. We in America may have a greater variety of forest weeds against which we must contend, but it is doubtful whether they are more persistent or troublesome than those met in the Old World. Anyhow, it is the usual thing for Swedish foresters to count upon a certain expense for assisting and cleaning each plantation made. It is a common practice in the more cultured part of the country to give some assistance to stands of N. S. R. origin, also.

Birch and aspen are the usual species that hinder development of desired coniferous stands. Mountain Ash, willows, gray alder, and hazel are sometimes unwelcome guests. One of the heavy items with this work in Sweden, where natural reproduction or direct seeding has been used, is thinning out clumps and groups where the desired trees stand too thick. Practically every spot sown stand shows two to several trees growing where only one is wanted. If these over-dense stands are not opened up, especially on medium or poor sites, the young stands stagnate for years and may even be permanently weakened or predisposed to disease.

In Swedish practice a number of special tools have been developed for assistance cutting. These, in general, look like hybrids between a butcher's meat cleaver and a Cuban machete. One type [74–229] near the latter in appearance, has a short ax-blade added on the back of the knife and near its tip, which makes it useful in pruning off limbs with an upward stroke where larger trees are trimmed up and allowed to stand; as is becoming the approved practice to a great extent wherever fuel wood can be marketed [3–391]. Wahlgren [74–227] recommends pulling out aspen and birch shoots and seedlings by the roots when the soil is moist and loose in spring. This would undoubtedly be a most effective method of eliminating these weeds, but is rather too toilsome for use in America. Mangling or barking aspen saplings has been found more effective toward checking their development than cutting them off. It has also been found [41–195] that removal of bark from boles of aspen trees on an area some seven or eight years before it is lumbered over, will cause them to die without sprouting, thus eliminating the species without excessive expense. In this method the bark is stripped off from breast height down to the root crown.

Assistance cutting is a practice that should find wider application in the eastern U. S. Foresters do not, as a rule, appreciate its importance. In fact, we do not even know how to correctly estimate the effect of the operation. This is commonly attempted by measurement of height growth on released or assisted trees and comparing this with that shown by nearly or similarly located unassisted trees. This only shows, however, one phase of the effect, and probably a minor one. Swedish investigators [3–394] emphasize the diameter increment. more vigorous rooting, improved average form and disease resistance of the assisted trees as the greatest gains from cleanings.

Since 1920 a quite general revision of opinion concerning birch has swept thru forestry circles of North Europe. Prior to that time the genus was looked upon in most localities, and by the profession generally, as unimportant or negative in value. It was not unusual for trained foresters to cut every birch tree out of their young coniferous stands. Studies of the forest humus and soil conditions, as well as investigation of volume increment during recent years, have demonstrated the great value of birch leaves and offal from the standpoint of permanent forest management. The considerable lime content of birch foliage is highly conducive to nitrification in the forest soil with maintenance of good physical and biotic conditions for thrifty tree growth. Even long decades after birch is cut from a given area, its influence toward desirable physico-chemical and mycotrophic relations is still felt and can be visualized concretely in growing stock increment.

For the above reasons, even in localities of Sweden where hardwoods are valueless, the forester still welcomes and strives to retain a few birch intermixt with the spruce and pine. In Germany, birch is now also being introduced artificially at considerable expense into coniferous forests where it was anathematized a few brief years ago. The Swedish people have always loved and prized the birch with its cheerful habit and contrast when compared to the dark conifers. It is well adapted to the climate everywhere, and will therefore quickly come to the aid of the forest manager who needs its services for maintenance of soil productivity. The ancient good which foresters saw in the birch as a nurse-tree, because of the favorable shelter its foliage cast, has now been greatly magnified, so it is no longer merely a guardian and protector of the valued timber trees in youth, but their food provider and physician all thru life.

CHAPTER VIII

ARTIFICIAL REGENERATION: GENERAL POLICY AND APPLICATION

SCANDINAVIA, and in particular Sweden, is the region of the world where direct seeding has met with greatest success in forestry. Our efforts to imitate this simple practice in America have largely resulted in failure, and will probably ever do so. The climate of Northwest, and even Central Europe, is well adapted to success of seeding under open and unsheltered conditions, while over the greater part of North America it is exactly the reverse, and our mid-summer or autumn drouths, combined with strong insolation and high temperatures, are usually fatal to the recently germinated seedlings. If any baby tree does survive the first growing season, it must still run the gauntlet of our very changeable and often severe winters; with frequent absence of snow and atmospheric humidity uniting with high winds, strong sunlight and alternate freezing, thawing and subsequent soil heaving, all threatening disaster to the tender organism.

In Sweden the heat of mid-summer and early autumn is modified by frequent rain, and humidity is always present to shield against sudden changes. Winter is characteristically mild, or the earth is steadily clad in a mantle of snow. In forest nursery practice it is never considered necessary to cover seed-beds with litter or other protective material during their first winter.

To American judgment it would seem that artificial regeneration is resorted to more frequently than need be, considering the ease of N. S. R. The reason for this often lies in the desire for a full stand or the rather commonly held opinion that it is as cheap to clearcut and denude an area, burn it over broadcast and then seed or plant up, as to use such cutting methods as may be necessary to get acceptable natural regrowth. The more even character of the new crop also appeals to many land owners.

Table LXVII, compiled from a Swedish Forestry Association [59–6/15/27–281] report, gives a good bird's-eye view of the extent to which artificially established forests occur in Sweden. Professional advice now predominantly favors N. S. R. wherever possible, but the impetus of seeding and planting is considerable and not capable of being immediately checked. The enthusiasm for this work is being wisely directed, so far as possible, toward reforestation of waste areas and such sites as are not likely to be regenerated completely or promptly by nature.

Total all artificially established forests equals 2,500,000 acres, of which 2,000,000 acres, or 80%, has been seeded or planted up since 1905.

The provincial Forest Protection Commissions have always been very active in encouragement of reforestation, especially as concerning areas that have long lain barren. (See Table II.) Areas that were laid waste prior to the origin of these commissions might in many provinces be planted up or seeded with free stock or seed supplied by these organizations and under their supervision. In addition to this, some provincial commissions would contribute $1.50 or more per acre toward the labor expense of the work. Of course, such generous treatment was not accorded land-owners for reforesting current cutting areas. These owners are by law in duty bound to regenerate the forest on such areas, if they are not wanted and suitable for agricultural use, and the commissions only extend help to the extent of advice and seed or planting stock at cost. Many provincial boards have been rather straitened for funds since 1920, and are less able to offer inducements toward reforestation. This fact has been reflected in reduced planting acitvity [59–12/15/27–544],—*e. g.*, in Jönköping province only 750 acres of old waste land was treated in 1926, while several years previous the average annual area of such lands reforested was near 2,500 acres.

TABLE LXVII.—Artificial Regeneration in Sweden

Ownership of Land and Character of Work Done	Time of Seeding or Planting	Area (acres)
Public—Reforestation	1871–1908	255,368
Public—Reinforced N. S. R.	1871–1908	147,506
Public—Reforestation of all Types	1909–1925	247,000
Total Public Seeding and Planting		649,874
Private Reforestation of all Types	Prior to 1905	248,000
Private Reforestation of all Types	1905–1925	1,811,240
Total Private Reforestation		2,059,240

Estimates based primarily upon the national forest survey work of 1924–'26, show that 1,000,000 acres of good forest soil are lying practically idle in Sweden today, and have been in that state since prior to 1905. These lands are not in the cold North to more than a very limited extent, but chiefly in the accessible southern part of the land where their productivity would be important to the national economy; which fact is illustrated by pointing out that this is an area 25% greater than all the forests of Denmark.

These old waste lands are realized by economists and foresters to constitute the imminent and legitimate field for artificial forest establishment. Proper cutting methods and preliminary measures in present forest stands should usually be ample to attain quite satisfactory new growth.

TREE SEEDS AND INVESTIGATION

The forest tree seed supply of Sweden is now controlled rather closely by governmental institutions. For many years an annual report has been issued about February 1st covering the seed prospects and crop of the foregoing year for each of the 142 forests (revir) into which the country is divided. This report is compiled by a specialist at the Forest Research Station and is carefully and accurately founded upon thousands of statements submitted by rangers, foresters and others. It gives, first of all, important tree species, both native and naturalized, their blooming and weather condition that might influence fruit-setting at that time. Abundance or absence of one-year-old cones on pines is next reported, and this is followed by data upon the current crop and its quality. Factors incidental to seed collection, extraction and storage for each species are next discussed. The seed supply on hand is finally estimated and compiled from reports made by the main extracting plants and seed handlers in government employ; *i. e.,* national forest service and the provincial forestry commissions. Table LXVIII gives the seed supply of Sweden in the hands of governmental agencies January 1, 1927,—exclusive of the current crop. The table illustrates the fact that seeds, and even unopened cones of pine, are commonly stored

TABLE LXVIII.—TYPICAL SEED INVENTORY OF SWEDISH FOREST RESEARCH INSTITUTE, COVERING SUPPLY OWNED BY GOVERNMENTAL AGENCIES [64–1926–18]

Locality and Agency	Quantity of Old Seed on Hand (pounds)	
	Pine	Spruce
South Sweden		
State Seed Extractory at Finnerödja	5,266	11,548
Provincial Forestry Commissions	36,896	53,605
Total for South Sweden	42,162	65,153
Middle Sweden		
State Extractory at Bispgarden	275	3,469
Provincial Forestry Commissions	12,238	15,418
Total for Middle Sweden	12,513	18,887
North Sweden		
State Extractory at Hällnäs	4	4,170
Provincial Forestry Commissions*	26	
Total for North Sweden	30	4,170
†Grand Total—Government Stored Seed	54,705	88,210

*Commissions only recently organized and just starting activities.

†Probably other stored seed is relatively small in amount. Considerable quantities of cones are collected and extracted by private individuals and corporations; even government foresters, rangers and forest laborers often collect and extract very good seed in seasons of full crops, using solar heat by means of the "Sun Cupboards" chiefly in extraction. (This seed is largely used currently however.)

by the government forest service for periods of three or four years. In this way full seed years of pine and spruce are utilized to the greatest possible extent, and a supply of climatically desirable seed is pretty well guaranteed. This work was organized to forestall repetition of earlier disappointments, when large areas were reforested with pine of German seed origin and absolutely unadapted to grow under Swedish conditions. A further measure in this direction is a relatively high tariff against imported seed of spruce and pine with the provision that all such seed shall be colored with *eosin* by customs officers at the port of entrance. This colors the seeds it comes in contact with, giving them a red cast, but has little or no effect on germinative ability. It is applied to seed by means of a syringe, with which the required quantity of the chemical is injected into the mass of seed with a minimum of disturbance to the package or container.

The forest tree seed needs of Sweden are probably in excess of 100,000 pounds per year, considering coniferous species alone; altho the amount of seed used today is likely less than in 1917. In that year governmental agencies alone used 31,277 pounds of pine seed and 70,600 pounds of spruce. Of course, practically all of the seed used by the provincial commissions went to reforest private owned lands. It is also notable [64–1917–68] that in 1917 more than 95% of the above quantity of seed was used in the southern third of Sweden. Today, 27,500 pounds is estimated as sufficient pine seed for one year's needs of the government, or the old seed held 12/31/1926 was enough for two years' work.

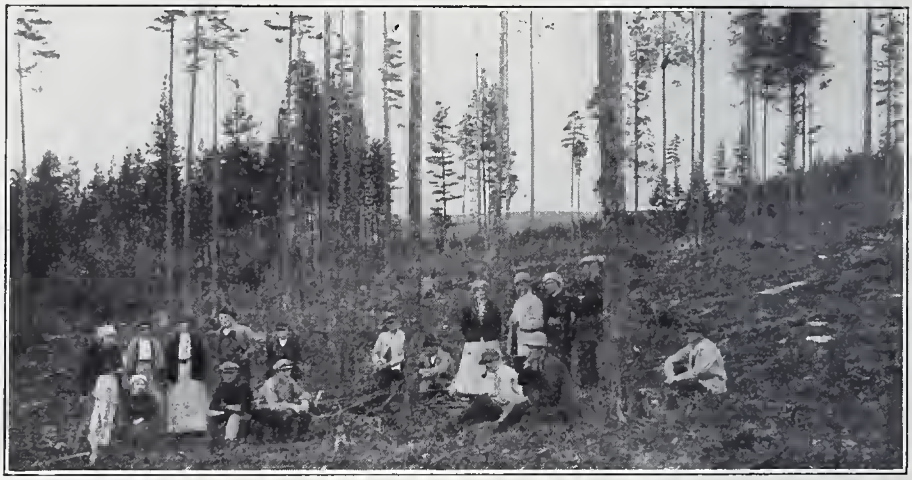

FIG. 9.—SCATTERED SEED-TREES ARE OFTEN USED TO SUPPLEMENT DIRECT SEEDING AND PLANTING IN SWEDISH FORESTS.

Planting crew is here seen on a typical cutting area upon a crown forest in North-central Sweden.

Foresters are not so solicitous concerning spruce seed as they are about the supply of pine. The reason for this difference lies in the fact that spruce seed of Central European origin gives rise to perfectly satisfactory forest stands everywhere in South and Middle Sweden. Any shortage in the local supply can therefore usually be made up by importation, and often at a cost below that for domestic seed.

The provincial forestry commissions have established seed extraction plants, so there is no lack of a considerable quantity of local seed, as a rule; altho the excess supply in the North will probably never be great. The yield of pine and spruce seed is not quite so great per bushel of cones in Sweden as it is in Central Europe, and labor costs are higher. This makes the cost of clean seed a little greater and renders sale of Scandinavian tree seed difficult on the markets of the world. However, the number of seeds per pound, as well as growth energy, are very high for this northern grown seed. For regions of similar or somewhat lower latitude, such seed undoubtedly surpasses that of Central European origin. Experiments in Pennsylvania show seedlings from Central Swedish seed develop rather more slowly than is the case when seed has originated further south. The little trees are also somewhat hardier and more resistant to disease. The habit of growth shown by Swedish pine is quite similar to that of Riga Scotch pine. The spruce seedlings are sensitive to sun and drouth injury, but capable of enduring dense shade over long years.

Some very thorough studies have been made on the subject of tree seed germination by Wibeck and others, especially with reference to the delayed germination exhibited by pine seed of extreme northern and alpine localities. The results in this connection can be summarized briefly as given below. This summary may justly be entitled " Wibeck's Law "—governing delayed germination of tree seed due to adverse climatic and weather conditions:

(1) When seed of a given species and crop, but from different latitudes and climatic regions is sown in a certain place, that from the less favorable origin, on the basis of the tree's life history, will show more delayed germination.

(2) Seed of given origin shows more delayed germination when sown in cold and unfavorable climatic localities than it does in more favorable regions.

The experience of forest planters in Sweden in respect to pine (*P. sylvestris*) has made them careful concerning origin of seed of other tree species. A number of studies on this subject have been made or are under way, of which the most complete and detailed has dealt with European Larch, after native pine and spruce, the most important conifer in the country, and one which has been planted considerably ever since the latter part of the seventeenth century. The great botanist, Carl von Linne (Linneus), recommended planting this tree and Swiss mountain pine on the alpine barrens of Lapland.

TABLE LXIX.—SAMPLE PLOTS OF EUROPEAN LARCH ARRANGED ACCORDING TO PROPORTION OF CROOKED TREES

General Data on Sample Plots				Distribution of Trees into Classes Based on Crookedness and Crown Form Primarily (%)						
Origin	Site Quality	Density of Canopy*	Age (yrs.)	w	a	b	(c)	c	d	e
				Unthinned Stands						
T	II	12	29	19	1.7		38	39	2.2	
T	III	10	31	12	10.7	9.2	15.6	38.2	8.6	5.7
T	III	13	29	23	8.	5.8	18.4	33.3	10.4	1.1
T	IV	12	20	32.6	4.5	2.3	12.1	31.9	16.6	
T	IV	12	25	27.2	4.7	2.1	17.6	31.5	7.5	9.4
T	I	11	24	53.3	1.3	2.6	11.9	28.4	.9	1.6
T	III	10	28	32.7	2.	14.4	15.1	25.8	9.4	.6
T	IV	11	36	41.7	6.	4.2	29.7	17.8	.6	
T	II	10	52	44.2	6.7	2.8	17.9	17.3	11.1	
T	II	9	28	21.8	13.9	5.2	28.7	16.5	11.3	2.6
T	III	6	36	51.6	29.5		5.7	11.9	1.3	
T	IV	8	30	51.3	6.9	.9	30.7	7.8	2.4	
S	V	12	57	45.2	11.3		17.8	6.4	12.9	6.4
S	II	9	44	43.3	16.4	2.3	11.8	6.	17.	3.2
S	II	10	80	24.5	21.4	27.	8.2	5.6	13.3	
S	?	?	30	45.2	26.2	23.8		4.8		
S	IV	12	57	45.6	24.	2.5	8.8	3.9	15.2	
S	III	11	57	40.	21.9	2.	11.4	2.9	20.9	.9
S	I	7	49	41.	21.4	12.9	6.2	2.8	15.2	.5
S	III	10	60	44.5	18.6	2.1	7.5	2.7	21.9	2.7
S	IV	10	60	53.5	12.8	.5	9.7	1.	22.	.5
S	II	10	57	56.4	12.8		5.3	1.	21.3	3.2

*The unusually high crown density for these larch stands is due to the great tendency of spruce and shade enduring hardwoods of minor importance to come in beneath them as an understory. The two crown levels computed together give a high density factor.

TABLE LXIX.—SAMPLE PLOTS OF EUROPEAN LARCH ARRANGED ACCORDING TO PROPORTION OF CROOKED TREES *(Continued)*

General Data on Sample Plots				Distribution of Trees into Classes based on Crookedness and Crown Form Primarily (%)						
Origin	Site Quality	Density of Canopy*	Age (yrs.)	w	a	b	(c)	c	d	e
				Thinned Stands						
T	II	8	30	21.7	4.1	1.3	27.3	44.4	1.2	
T	III	10	68	29.3	5.1	8.1	11.1	44.4	2.	
T	III	9	68	5.3		21.1	36.8	36.8		
T	II	14	53	27.8	7.4	18.4	7.4	25.9	23.1	
S	II	4	80	43	7.8	7.8	7.8	21.1	7.8	4.7
S	III	7	83	63.9	9.2	1.4	1.4	19.9	4.2	
T	II	10	37	40.5	7.6	.3	4.5	18.1	24.2	4.8
T	III	9	37	59.7	13.8	2.6	2.8	17.7	2.6	.8
S	I	10	55	43.3	17.3	5.4	9.8	15.8	6.1	2.3
S	I	14	69	63.1	12.6	1.	4.9	11.6	5.8	1.
T	III	11	37	73.4	8.7		1.4	10.4	5.7	.7
S	I	8	60	50.2	24.9		7.2	7.2	7.3	3.2
T	III	9	36	78.1	7.4	2.2	1.7	6.1	3.9	.6
S	III	9	71	50.	28.9	5.8	3.8	3.8	7.7	
T	III	10	42	54.5	7.6	3.		6.1	4.6	24.2

*The unusually high crown density for these larch stands is due to the great tendency of spruce and shade enduring hardwoods of minor importance to come in beneath them as an understory. The two crown levels computed together give a high density factor.

The splendid monograph by G. Schotte on the larches (Lärken) was worked up at the suggestion of the national Forest Service (Domänstyrelsen) and is a model of its kind, combining both technical and practical viewpoints [54–1917–531]. One of the major phases studied was the cause for the wide variation in growth rate, bole straightness and disease resistance shown by European larch in Scandinavia. The investigation demonstrated that all three of these features were correlated closely with origin of the seed. Moreover, trees or plantations that were satisfactory in one of the above respects were also good in the others. It was, therefore, only needful to determine the source of seed used in establishing good plantations of larch, and in this way elaborate definite rules for seed purchases in the future; with every certainty that resultant plantings will be better and more satisfactory in every way than many of the present stands from parentage ill-adapted to North Atlantic and Baltic breezes.

Most of the older larch stands in Sweden are from seed of Tyrolian or Scotch origin. Prof. Schotte concluded that the latter race of European larch was far superior to the former. Because of the increasing importance of this tree in the northern Mississippi Valley and the eastern U. S., Table LXIX is submitted to emphasize the grounds for the above conclusion. It may still be true, however, that because of climatic differences the Tyrolian race might grow with good form in America, in spite of the poor record it has made in Northwest Europe. In fact, most of the larch in the northeastern U. S. is of Austrian or German origin, and yet it is rare that crooked trees occur. However, Schotte explains the superiority of Scotch larch by its heredity and inbreeding, and if he is correct, this tree should be best under all conditions, due to qualities inherent in the germ-plasm.

In Table LXIX, stands of the Scotch race are designated with *S* and Tyrolian with *T*. The column headings *W* means well-formed trees; *a* means trees with asymmetrical crowns, usually all on one side of the bole; *b* means broad-crowned wolf-type trees; *c* means very crooked trees, only suitable for fuel-wood; (*c*) means crooked trees, but still capable of use for poles or even saw-logs; *d* means trees with damaged or deformed crowns, due usually to contact with competing neighbors; *e* means diseased and dead trees.

It is certainly impossible to look at the foregoing summary, espe-

TABLE LXX.—GROWTH-RATE COMPARISON OF SCOTCH AND TYROLIAN LARCH IN EARLY LIFE

Variety or Race	Age (yrs.)	Heights (ft.)		
		Maximum	Minimum	Average
Scotch	5	8.37	1.64	5.38
Tyrolian	5	5.71	.89	2.13
Scotch	12	19.01	7.55	13.32
Tyrolian	12	17.06	4.59	10.43

cially the significant column *c,* and not agree with Schotte as to the general excellency of the Scotch strain of larch.

It is also maintained that the Scotch larch surpasses Tyrolian in rate of growth, but direct and definite data on this score is not so easily secured, because of the many variable factors entering when comparing stands grown at a distance from each other. At Omberg, however, are young mixt stands established from purchased Tyrolian seed and a gift of Scotch seed from the Royal Scottish Arboricultural Society. These trees are being watched with great interest as they grow up together. Table LXX gives early results and seems to indicate Scotch superiority [54–613] as to rapidity of starting.

At twelve years of age 31.5% of the Tyrolian larch are very crooked and 19.5% are slightly so. Corresponding values for Scotch are only 1.5% and 10.3%.

The growth of the two races of larch in later life is illustrated by Table LXXI [54–576 and 594] from two sample-plots on Quality II sites and each fifty-seven years old. This bears out the claim that the Scotch larch is better as to increment, but it shows a poorer form factor than does the Tyrolian stand. This fact is explained probably by the Scotch stand growing upon a site that is rather swampy, being of drained bog origin and also quite exposed as to wind conditions.

It is pointed out by Prof. Schotte that not all the larch now growing in Scotland is of the old Scottish race of approved excellence. In relatively recent years considerable larch has been planted in the British Isles from seed of Central European source, and seed from these younger trees is now coming on the market. It is naturally little if at all superior to seed purchased direct from Tyrol.

The high quality of the original Scotch larch is a triumph of plant breeding in the forestry world and probably the first, if not the only one, on record. It is claimed by some writers that all the old larch trees in Scotland were the offspring of two specimens still standing in 1920 at Dunkeld, Scotland. These two trees were the final survivors and choice individuals from a small number brought in his traveling bag from London by a gentleman named Menzies, in 1738, and distributed among his friends. Five were received by the Duke of Athol and were treasured highly for many years; in fact, at first they were housed in a greenhouse. Scotch gardeners and arboriculturists for more than a century collected seed from the choicest specimens of their larch and cut out those trees in their stands that were inferior as to growth rate and bole form. In this way the excellence of the Scotch variety was built up. It is likely that the original trees from London were grown from seed collected in the Alps and purchased in France, Italy or possibly Switzerland.

It has also been the experience in Sweden, as well as Germany, that the Silesian race of European larch, growing on the higher mountains of Poland and at the north limit of range for the species, is superior to the Tyrolian and Alpine strains of the tree. Schotte adds, however, that larch seed purchased in Silesia, unless it be from honest collectors, may only be Silesian in so far that it has resided

TABLE LXXI.—COMPARISON OF LARCH STANDS IN SWEDEN OF SCOTCH AND TYROLIAN SEED ORIGIN, BOTH ON SITE II SOIL AND AT AGE OF FIFTY-SEVEN YEARS (UNTHINNED)

Species and Crown Status	Number Boles per A.	Actual Area at B. H. per A. (sq. ft.)	Volume (cu. ft.) per A.	Average D. B. H. (in.)	Average Height (ft.)	Average Form-factors
Larch Stand of Tyrolian Origin						
Larch (entire stand)	488	149	5,174	7.5	69.9	.495
Spruce (entire stand)	302	29	600	4.2	40.7	.503
Total Trees per A.	790	178	5,774			
Larch (dominant trees)	324	127	4,489	8.5	72.2	.491
Spruce (dominant trees)	3	1	29	7.6	68.2	.481
Larch Stand of Scotch Origin						
Larch (entire stand) Total Trees per A.	355	164	6,160	9.2	77.1	.486
Larch (dominant trees only)	313	156	5,860	9.5	77.4	.474

there a short time in order to achieve a considerable price increment. To summarize: the advice on European larch seed is,—" Buy that of the valuable Scotch or Silesian strain if it can be certainly secured, otherwise collect seeds locally from known trees of best form and development growing in stands from which inferior individuals have been eliminated." This is good advice for forestry in America and applies to every species just as aptly as it does to European larch.

FOREST NURSERIES

Probably Swedish nursery practices and results attained are not, on the whole, in advance of those obtaining in the U. S. or Canada. We have practically imported from Germany all the technique developed there during two centuries, and then in course of two decades made such changes as harmonize with our ideas of labor efficiency, mechanical methods, soil treatment, water needs and fungus problems. In this way American forest nursery practice has progressed further by far than any other phase of the science. The Swedish people are also gifted with mechanical common sense and rarely follow blindly in the footsteps of precedent. It is thus notable that forest nurseries were slow to develop, and have tended to be relied upon only under special conditions when direct seeding suffered under some more or less unusual disadvantage; as *e. g., re* larch. Seed of this tree is quite expensive, and its rate of germination low, hence in order to get best results, this tree is rarely seeded direct.

Because of the relatively slow growth of coniferous tree seedlings in early life, a goodly proportion of the spruce, fir and larch stock planted has been transplanted in the nursery. Even pine transplants are sometimes used. Transplanting is done usually with a simple notched board in which seedlings are held by a tightly stretched cord. Trees are commonly set in rows across beds of about four feet width. The trenches for setting trees are often opened with a peculiar spade or huge trowel that works very effectively in good soil. This spade has a heart-shaped blade about sixteen inches long and ten inches wide near the top. The blade is perfectly flat and stands in a plane parallel to that of the d-type handle, but is set back about two inches. The handle is straight. The cost of transplanting,—work largely done by boys and women,—averages around thirty-seven cents per 1,000 trees set, which is less than the same work costs in America.

TABLE LXXII.—COSTS OF GROWING NURSERY STOCK FOR FOREST PLANTING IN SWEDEN

Species and Age-Class	Cost per 1,000
Scotch Pine and Norway Spruce (2 yrs. old)	$.40
Scotch Pine (1–1) Transplants	2.35
Norway Spruce (2–1) Transplants	2.59
Norway Spruce (2–2) Transplants	5.45

Table LXXII shows representative costs for transplant stock grown in Swedish forest nurseries. All figures may seem low, yet this is not due to cheap labor rates, but rather in spite of it; for the labor is not nearly as efficient in general as the better paid labor in the U. S.,—even on a monetary basis of comparison. The short growing season requires only two or three weedings. Steady cold weather in winter with plenty of heavy snow, which rarely or never drifts off the beds, eliminates winter losses entirely and requires no litter cover at any stage in the growing of stock. It is rare even that seed beds are covered prior to germination, as hard beating rains are very infrequent and the long hours of daylight stimulate quick germination whenever seed is not sown too early.

Seedlings are grown almost universally in drill rows. It was long customary to make up beds and have rows running across them. In many nurseries now no neds are made up, especially for pine, but seed is sown in long rows, spaced about eight inches apart, using a Planet, Jr., or similar hand sowing and covering machine. This change much expedites the task of seeding, but is probably not productive of as many or quite so good trees as are grown in beds where the best soil is heaped up and carefully prepared for reception of the seed.

Many investigations are recorded in the forest nursery field, and some of these show results that might be helpful to us in America, especially for dealing with the European species and similar trees.

The use of charcoal braize, or fine screenings from the bottom of charcoal pits, as well as sawdust for covering seed and modifying

TABLE LXXIII.—RESULTS OF VARIOUS METHODS OF FOREST NURSERY PRACTICE; BJURFORS, SWEDEN

(All seed sown in 2.4 in. broad drills made with a pressing board)

Scotch Pine	Plant Percent
Seed covered .2 in. deep with soil from beds	49%
Seed covered .6 in. deep with soil from beds	54
Seed covered .8 in. deep with soil from beds	58
Seed covered .6 in. deep as above and mulched with spruce brush during germination	64
Seed covered .4 in. deep with bed soil and shaded with lath shades during germination	39
Seed covered .4 in. deep, with clean gravel	17
Seed covered .4 in. deep, with fine sifted sandy loam	27
Seed covered .4 in. deep, with sawdust and lath shaded during germination	53
Seed sown in drills .8 in. deep and 1.5 in. wide covered with moss	25
Seed sown in drills .8 in. deep and 1.5 in. wide covered with marsh hay	44

Norway Spruce

Beds covered with spruce brush yielded twice as many trees at end of 1st yr. as uncovered beds.

	Plant Percent	
	.8 In ~~4~~ in. Deep Drills	.4 In ~~8~~ in. Deep Drills
Seeds covered with sawdust	20%	26%
Seeds covered with fine sifted loam		18%
Seeds covered with seed-bed soil	16%	
Seeds covered with unsifted compost		24%
Seeds covered with coniferous needles	12%	
Seeds covered with sphagnum moss	7%	

soils, has been tried out in Sweden with the same favorable results obtained by the Department of Forests and Waters in Pennsylvania. Table LXXIII seems to indicate that more careful practices would yield considerably better results than are now generally secured in Swedish forest nurseries.

Wahlgren concluded that covering spruce beds with spruce boughs during germination resulted in stronger and better plants, so that even at the end of the second year a considerable advantage existed. At that time 100 plants from beds covered with boughs during germination weighed 24.7 grams for roots and 52.5 grams for tops, while from uncovered beds the corresponding weights were 20.1 grams and 34.1 grams. When these two-year-old spruce seedlings were graded into three quality classes results were as follows:

Beds covered with brush yielded 21% good, 50% medium and 29% weak trees, while uncovered beds yielded 2% good, 37% medium and 61% weak trees.

Rolling beds after sowing has proven detrimental always, except possibly on loose sandy soils.

Growing seedlings of aspen has been one of the triumphs of Swedish forest nursery practice. All of the genus *Populus* has characteristic light seed with fleeting vitality and most of the more important species lend themselves readily to propagation vegetatively by cuttings. Certain species, however, as *P. tremuloides, grandidentata* and *tremula,* do not root successfully from cuttings, hence it is sometimes desirable that the genera be reproduced artificially by seed. In this connection collection of seed from trees in groups where both sexes are represented is important. The seed capsules are gathered just as soon as the tips begin to open. When spread out in a heated room or airy loft they quickly open so the light seed and cotton can be separated from the extraneous material. It should be sown at once in shallow drills and wet down carefully, thereafter a thin cover or partial cover of fine sandy loam is sifted over the drills and a thin layer of spruce boughs or newsprint paper is laid over the beds to retain moisture until germination occurs, which is within one to four days. Lath shades are then raised over the beds and the covering material removed. For a week or two it may be desirable to spread a portion of the spruce brush or stretch cheese cloth over the lath shades, as the seedlings are almost minute in size and very tender. If weather is sunny or windy, beds should be watered daily. Development of these tender trees is rapid, altho somewhat irregular, and in a month or so they appreciate full sunlight intensity [74–717].

Small nurseries of an acre or less up to five or six acres are the rule in Sweden. Temporary nurseries on the site where the planting work is to be done are often met. The neatness so typical of German forest nurseries is sometimes lacking, but efficiency in producing trees at low cost is the usual rule.

The provincial forestry commissions maintain numerous small nurseries. Typical such developments can be seen at Solna, near

Stockholm, at Mora, in Dalarne, and near Visby, on the island of Gottland.

FOREST PLANTING

As in America and elsewhere, planting has made gains in Sweden over direct seeding during the third decade of the present century. Lower cost of planting stock due to better nursery technique and organization, combined with man's anxiety to get prompt results, works always in favor of forest planting, even when land owners realize that it may expose the stands to serious fungus attacks later in life.

Because of the increasing interest felt for planting, numerous different tools and methods of planting have been elaborated in Sweden and are being used there side by side with those of German origin [74–203]. It is surprising to an American forester, however, that the ax-mattock, so useful and generally adopted in the U. S., is practically unknown in Scandinavia. The mattock is used, but it is a futile German affair without either stonepick or root-cutting ax blade to balance the hoe blade and nearly double the efficiency of labor, when roots and ground vegetation are present. Planting with a heavy staff or bar and filling the hole with earth carried from a distance or dug from another hole nearby, is said by Amilon [3–308] to be the commonest method. This seems like a tedious and unsatisfactory way to set trees. In fact, it has obvious disadvantages from every standpoint. The earth is compacted in making the hole, so the roots tend to concentrate the growth of early years, in the small and relatively loose mass of soil used to fill the hole when planting. This is especially the case, if this soil be compost, loam or rotted peat high in humus content and hence more attractive to the roots than the surrounding relatively sterile mineral earth. It is possible, however, that the deformation of the root system (see discussion in preceding chapter) due to this planting method has been over-estimated. Amilon holds that, providing trees do not die during the first year or two, as the result of crushing and cramping of their roots at time of transplanting, they will likely suffer no ill effects later [59–12/15/27–545]. He likewise pays his iconoclastic respects to the prevalent tradition that trees should be set in the middle of the hole and not against the side wall. Table LXXIV exhibits data to prove that trees set against the side of holes are capable of as good growth, if not better than shown by trees set in the middle. The latter method of setting requires more time and care than the former, and is said by Amilon to be advantageous only in so far as roots are less likely to be crushed against stone in the planting operation.

The best type of bar developed for this method of forest planting has a heavy and rather broad nearly cylindrical bit with rapidly tapering conical point. Its other end is sometimes equipped with a strong three-tine iron rake that is very useful for clearing away ground vegetation and débris. The length of the bar is four feet with six-inch long steel bit, whose greatest diameter is two inches.

Planting balled stock is rather common in Sweden. Cylindrical spades and similar special tools are often used. The completion of plantations made by spot-seeding is often accomplished by lifting trees from spots where two or several seedlings have developed and setting this stock in the fail place~~d~~s. Such work is done with tools that remove a ball of soil with the seedling and thus slow down its growth in the least possible degree.

TABLE LXXIV.—DEVELOPMENT OF PLANTED TREES AS AFFECTED BY PLANTING METHOD AND DEGREE OF ROOT DEFORMITY (SCOTCH PINE)

Age at Time of Study (yrs.)	Number of Trees Examined	Trees with Normal Root Systems		Trees with Roots Slightly Deformed		Trees with Roots Strongly Deformed	
		Growth of Trees (inches)					
		Average Total Height	Length of Top Shoot	Average Total Height	Length of Top Shoot	Average Total Height	Length of Top Shoot
Trees Planted Against Side of Holes							
8 and 9	55	7.4	2.1	8.5	2.2	8.5	2.1
10 and 11	159	27.5	5.2	26.3	4.8	28.3	5.4
12	124	30.6	5.4	29.6	5.6	39.9	5.8
Trees Planted in Middle of Holes							
8 and 9	253	10.8	3.4	12.3	3.3	13.6	3.6
10 and 11	101	11.9	2.8	15.6	3.4	16.4	3.8
12	126	24.5	4.1	27.4	5.4	30.7	5.7

Wahlgren estimates that two-year-old balled plants can be taken up in a nearby nursery and set in permanent plantations at a cost of $5.73 per 1,000, and nearly half this sum is the cost of growing the plants. It would seem to be flattering tribute to the good organization of Swedish forest planting, as well as labor efficiency, if this kind of work can be accomplished at a cost below $3.00 per 1,000 trees. No one can deny the good technique of forest planting by this method. Results are always excellent [74–204]. The tendency the country over, and especially toward the north, is said to be strongly toward naked rooted plants, however. It is doubtful, therefore, whether Swedish experience with balled stock justifies American imitation. The chief argument favoring such planting in Europe is the more nearly normal rootsystem developed by trees, as compared to those planted otherwise.

The most ambitious project with balled stock was that elaborated by Nils Berner [3–317], which included nursery as well as planting practice, and was systematized to the extent of being practically mechanical. Heavy flats of plank were made up with handles at each end and of such size as to hold 20 x 25 light cardboard cartons with open ends and holes punched or stamped thru all four sides. These cartons, to the number of 500, were set on end in each flat in such manner that the side holes never coincided with adjacent ones.

Earth was then shoveled onto the flat, shaken and mechanically tamped down into each carton. A punched metal plate was then put in position over the checkerboard looking flat, after this had been covered with a pane of glass or unpunched metal plate. Seed was then brushed over the punched plate and the holes in it were of such size as to retain a desired number of seeds, which fell thru into the respective paper cartoons when the lower glass or metal plate was pulled from beneath. Usually four or five seeds went into each carton and they were covered by sifting earth over the flat. These flats were then set away side by side and presented the appearance of ordinary plank curbed nursery beds. They were treated exactly as we would treat broadcast sown nursery beds for the first year, except that cartons with more than one tree were usually thinned, and those with none were filled up so as to eliminate all blanks. At end of one or two growing seasons the flats, with 500 trees growing in each, were shipped to the planting site and the cartons set in a specially prepared hole that just fitted them. By this time the paperboard cartons are to some extent decomposed, but whether this is true or not, the holes punched thru the sides give roots ample opportunity to spread. The flats full of trees and earth were readily shipped by rail or motor truck, as they were provided with tops that were easily put in place and permitted stacking flats upon each other.

The future of forest planting in Scandinavia is assured. With increasing population and progress continuing along all forestry lines as in the past, vast areas of waste lands, especially toward the north, will be drained or otherwise reclaimed and afforested by planting. For altho seeding is now highly important in Sweden, as further south, the constant tendency will be to go over to planting as the approved and most intensive artificial method of regenerating the forest. Ultimately the silvicultural plans will call for N. S. R. with reënforcement by planting where necessary. The great extent of the unproductive forest lands of Sweden is set forth in Table LXXV. Much of this land is owned by the public, and agitation for its reclamation and improvement is frequently voiced in the press and parliament. It is doubtless true that much of this land is irreclaimable from an economic standpoint at present, but time is ever on the side of progress in these latter days, when man asserts more strongly every decade his ability to master nature and make every clime pay tribute to his desires. The extreme boreal location of much of the unproductive forest land of Sweden is shown in Table LXXVI, and is the main reason why little has been done to bring these areas under forest. It has always been an axiom in central administrative forestry circles that every project should pay its way. This is a motto that public forestry leaders in America might well ponder upon.

DIRECT SEEDING

Traditionally, this method of artificial forest establishment has almost national prestige in Sweden, as heretofore explained. It will

TABLE LXXV.—PRODUCTIVE AND UNPRODUCTIVE FOREST LAND IN SWEDEN—1923 [26–183]

Ownership	Total Forest Areas		Productive		Unproductive	
	(acres)	(% of all)	(acres)	(% of all)	(acres)	(% of all)
State Forests	15,409,000	17.2	9,387,130	15.8	6,021,870	19.8
Crown Lands, Unallotted and Unsurveyed	10,762,000	12.	341,270	0.6*	10,420,730	34.4
Other Public Forest	6,663,000	7.4	3,086,720	5.2	3,576,280	11.8
Private	56,822,000	63.4	46,525,000	78.4	10,297,000	34.
Totals	89,656,000	100%	59,340,120	100%	30,315,880	100%

*Much of this lies above timberline or is rocky skerry and cliff land.

TABLE LXXVI.—LOCATION AND PRESENT PRODUCTIVITY OF SWEDISH STATE FOREST LAND—1923

Province or Region	Total State Forests		Productive		Unproductive	
	(acres)	%	(acres)	%	(acres)	%
Norbottens (Extreme North)	8,606,000	55.8	4,756,000	50.7	3,850,000	64.
Vesterbottens (Middle Norrland	3,347,000	21.7	2,252,400	24.	1,094,600	18.2
Lower Norrland	1,043,000	6.8	783,350	8.4	259,650	4.3
Kopparbergs (Middle Sweden)	1,184,000	7.7	702,310	7.4	481,690	8.
Southern Sweden	1,230,000	8.	892,830	9.5	337,170	5.5
Totals	15,410,000	100%	9,386,890	100%	6,023,100	100%

probably long be important because of adaptation to climate, but will slowly give place to planting as forestry becomes more intensive. In the extreme north and on alpine areas it will likely tend to persist as an aid toward improvement of the protection forests where intensive practices will never be justified. Pine can scarcely hold its own on these areas and may require artificial regeneration. It grows with good form and is quite hardy even beyond the limit of natural seeding. Table LXXVII is submitted to show results attained by direct seeding at the cold limit for pine [59–9/1/1927–402].

Spot seeding (*Fläcksodd* or *rutsodd*) is the most recommended and popular method. Broadcast sowing has long been recognized as entirely too prodigal of seed. This same criticism to a less degree applies to seeding in rows, and custom has not yet been weakened to the extent that motor or horse power may displace human labor in a field where it has long held sway. Sowing in rows also fails to give the seed the perfect bed for growth which foresters have been accustomed to attain by use of hand tools. However, row-seeding is gaining in popularity and implements that expedite the operation or withstand the struggle with rocks and débris better than standard farm forms have been developed and are coming into use [74–134]. Most of these implements distribute the seed as well as cultivate the soil.

Numerous special tools have been invented in Sweden for spot preparation with that method of seeding [74–121]. One of these is horsedrawn and automatic [3–288], but not especially good as concerns the character of the seed-bed it makes. Many of the hand tools possess a seed container attached to their handle or above and back of the digging bit. Such tools also invariably have a mechanical contrivance that will measure out and distribute a desired quantity of seed over the spot after it is prepared. The general trouble with such tools lies in their clumsiness or the fact that the seeding apparatus is so liable to be broken or rendered inaccurate, due to the hard usage they must withstand. Mud may clog the seeder and make it necessary to resow large areas or have many blank spots. It is, therefore, usually customary to use the simpler types of tools and have a boy or woman complete the operation by following the spot-maker to shake out and cover the wanted amount of seed. Seed-flasks of tin are often used in this operation [74–119 and 3–295].

TABLE LXXVII.—DIRECT SEEDING OF PINE NEAR KIRUNA, NORTH SWEDEN AT ITS COLD LIMIT OF RANGE

Seeding Method	Plants at End of Tenth Growing Season				
	Number Per Spot (Averages)	% of Blank Spots	Plant % (of all seeds)	Largest Plants Total Height (in.)	Per Spot 1926–27 Growth (in.)
Spots with Deep Cultivation	4.9	5.4	12.2	9.8	4.2
Spots with Shallow Culture	6.7	4.9	16.8	10.3	5.1
Narrow Strips and Deep Cultivation	7.5	4.	18.8	8.9	3.8
Strips and Shallow Cultivation	6.3	10.9	15.8	9.1	4.
Spots with Shallow Culture	7.4	3.4	16.4	12.1	6.

Schager gives an interesting table, LXXVIII, showing the average cost of artificial forest establishment in Sweden on private owned lands over a period of ten years [52–128]. This may explain the considerable variation in the amount of planting and seeding done during different years, as well as the tenacity with which seeding directly in the forest maintains its popularity; since it is notable that while the cost of seeding has increased 300%, planting has increased 400%.

It is generally held that planting requires greater care and skill on the part of the executing labor than does direct seeding. Not only do careless laborers permit the roots of trees to become dry, but in digging many are often injured or mangled, so fungi may gain entrance to the central pith region of the tree and work havoc in later years. This is also a danger when the roots, especially when planting large stock, are set in a cramped unnatural position. Even at best, when trees are dug with perfect technique, transplanting in the field always destroys the balance that has developed between roots and top in the nursery, as this is only adapted to serve under the special soil and meteoric conditions of the nursery and is rarely if ever exactly suited to conditions of the planting site. The consequent adjustments are often fraught with dangers and disadvantages to the organism. Such reasons as the foregoing incline Swedish forest owners to cling to direct seeding, unless special circumstances make planting very alluring.

TABLE LXXVIII.—COST OF SEEDING AND PLANTING ON PRIVATE FORESTS IN SWEDEN,—(AVERAGES)

Year	Direct Seeding (Cost per acre)	Planting (Cost per acre)
1911	$2.08	$3.39
1912	3.50	3.81
1913	2.51	4.48
1914	2.73	4.04
1915	2.30	5.36
1916	2.73	3.61
1917	2.84	6.78
1918	3.93	9.18
1919	5.46	10.05
1920	8.63	17.38

THE CHOICE OF REPRODUCTION METHODS

The factors that control forestry practices in Sweden may be briefly summarized:

1. Landowners are conservative by nature and follow custom rather than theoretical ideals concerning "Highest soil rent."
2. Compulsion is almost necessary to bring about general change in forest management.
3. Clearcutting is rarely attempted in regions where market conditions are poor.
4. On the other hand, clearcutting is usually the owner's choice where markets will absorb small material.
5. Spruce is better adapted to selection forestry than pine, and because of this the development of the pulp and paper industry has encouraged selection treatment.
6. Where raw humus is serious, clearcutting is advisable, but
7. where climate and soil are otherwise adverse, selection felling is the usual rule.
8. The tendency on many forest properties is toward mixt management, treating each area on its merits, relying wherever possible upon N. S. R. and reënforcing artificially when necessary.

CHAPTER IX

THINNING AND IMPROVEMENT CUTTINGS

IN THESE phases of forestry, Sweden has made rapid strides since the dawn of the present century. Prior thereto such activities had no standing in Swedish forest management except for rare and desultory, or often misdirected practices by farm woodlot owners, and in a limited portion of South Sweden where Danish and German influence and example has weight. It is not unusual now in South and Central Sweden, on both public and private forest properties, to find half or more of the annual wood volume cut consisting of thinnings.

Very dense stands are typical of regeneration on favorable sites in the climate of Scandinavia. It is almost unbelievable how close trees of an intolerant species, such as Scotch pine, will stand during early life. The Swedish Forest Research Station has careful data on their permanent sample plot No. 3 which illustrates how these stands stagnate when unthinned. This data is given in Table LXXIX, with a comparison to show the effect of thinning on an adjacent plot.

TABLE LXXIX.—DENSITY OF PINE STANDS IN LAPLAND AND EFFECTS OF THINNING

Age of Stand, etc., (yrs.)	Live Trees per A.	Sectional Area at B. H. (sq. ft.)	Volume per A. (cu. ft.)
	Unthinned Stand		
54	3,282	150	2,758
61	*1,732	137*	2,772
	Thinned Stand		
54	5,461	187	3,388
61	1,612	131	2,646
Taken out as Thinnings	3,849	67	1,000

*Great loss of trees due to natural thinning at this critical age of the stand.

Recent experience in Sweden, especially in the central and northern portions of the country, indicate that soil temperature during the growing season is very often the limiting factor of increment in the forests [39]. Heavy thinning of these boreal stands permits the sun to pierce the canopy and warm up the soil. This is naturally a matter of great importance, as it lengthens the growing season considerably. Heavy thinnings also permit the snow to reach the earth in winter, covering it deeply instead of being largely retained on the dense canopy of the trees; to melt there or evaporate. Actual measurements of the depth to which frost affects the soil show the advantage of thinning in this respect. As the soil actually freezes less than half as deep and in addition the warming of the soil in spring is so much better in the thinned stands, that the greater quantity of snow on the ground melts away earlier than the less amount under unthinned ones. Raw humus is one of the gravest obstacles to forest increment in cold, wet regions. Warming the soil by heavy thinning decomposes the acid accumulation of vegetable matter that tends to retain much fertility bound up and unavailable to the growing tree stands. The rooting of trees is largely controlled by soil temperature conditions. This is especially true of Scotch pine. It is a typical flat-rooter at the cold limit of its range, but a tap-rooter elsewhere. Heavy thinning has been observed to influence depth of rooting most favorably.

The most extensive practical application of heavy thinning with the object of warming the soil is that of Forester Erik Ronge in the employ of the Kramfors Company, a corporation engaged in saw-milling and pulp manufacture in the North. This concern has been making primary thinnings on its lands at the rate of 5,000 acres or more annually. These operations yield practically no return at the time, as the trees in the characteristically dense young stands are too small for use. It is the aim in this work to space trees of twenty feet or less in height about eight feet apart, while larger trees are spaced ten feet or more. Labor is paid fourteen cents per hour, and the cost per acre is about $1.50 [52].

Actual sample plot studies show stands seventy years old that were growing at the rate per acre of twenty-eight cubic feet annually (1.22%) before thinning, but fourteen years later, after this radical treatment, were making a current annual increment of eighty-two cubic feet (4.17%). Another pine stand, when thinned at fifty-six years old, showed fifty-eight cubic feet (1.6%) annual growth, but nine years later it had risen to 134 cubic feet per acre (7.6%). In these instances the number of boles per acre was reduced respectively from 308 to 189 and 1,003 to 360.

These figures for increased increment are very much higher than those from the Forest Research Station's plot given in Table LXXIX. That, however, was an example of light thinning and stands in marked contrast to the heavy practice used by Ronge.

THEORY AND PRACTICE OF THINNING

The results attained by the research men, as well as practitioners in the forest, strongly indicate the advantage of heavy over light thinning in the cold and moist climate which predominates over most of Scandinavia. This conclusion is very agreeable to the forest owner and enables him to thin at a handsome profit in most localities, especially where charcoal is marketable or transportation facilities permit sale of birch for fuel. Pulpwood is capable of going to market now on an equal basis with saw-timber nearly everywhere.

The foregoing conclusions concerning heavy thinning are applicable over considerable forest areas in Canada and Alaska, but can be a delusion so far as more southern forests in a continental climate are concerned. Even in Sweden, the most rabid advocates of heavy cutting go much more lightly when dealing with stands on dry south slopes than on flat lands or moist areas. It is also true that the greatest part of Swedish forests in the aggregate are rather understocked than fully stocked or overstocked. On all the vast areas of stands considerably subnormal in density, shrubby heath plants, mosses and grasses are commonly in possession. These forest weeds are all favored by light, and where they occur only very mild thinning, if any, can be done without sacrificing increment.

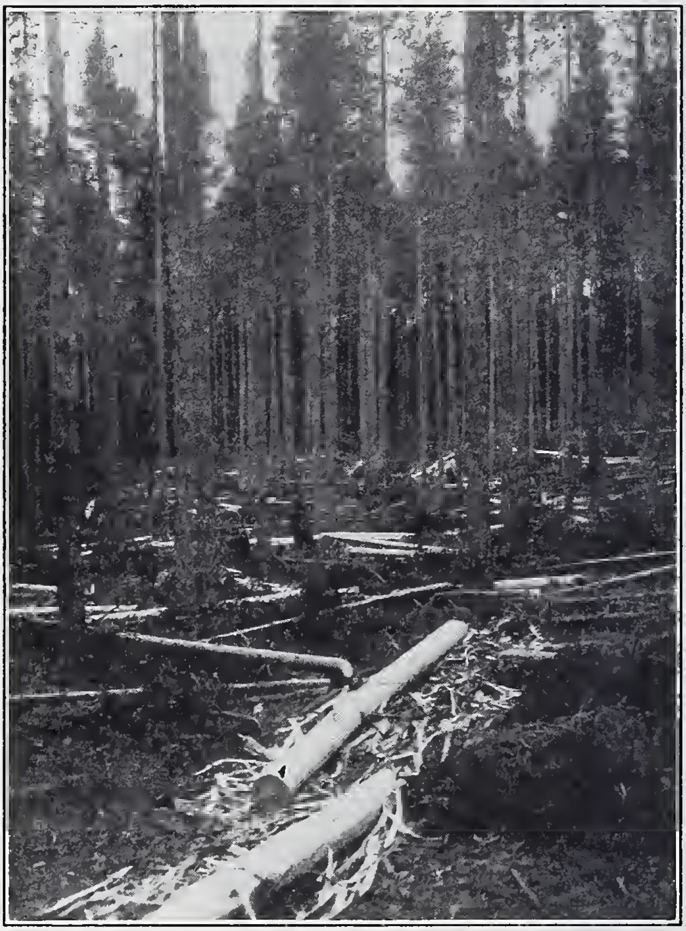

FIG. 10.—TYPICAL ACCRETION CUTTING IN PINE FORESTS OF CENTRAL SWEDEN.

Such a cutting stimulates the most rapid growth of the trees that remain and results in very heavy crops of seed as soon as the trees get well accustomed to the full open sunlight.

Thinning from above predominates in Swedish practice, or variations of it known as " free thinning " and " Danish thinning." The first consists in choosing final crop trees of good growth and form at an early age and then cutting away both large and small neighbors from time to time, as may be necessary to the optimum increment of the chosen stems. Danish thinning is based on the same fundamental idea, but is guided in practice by classification of the trees on an area into four or five classes. The explanation of these classes gives an excellent concept of the method [55–245] :

(1) *Principal trees.* These are the essential part of the stand. Special pains are taken to favor them so that at the time of final felling they may show optimum development, both as to quantity and quality of increment. *These trees are retained.*

(2) *Detrimental associate trees* are such as work injury to the stand,—either the principal trees or other associates. They shade, whip or crowd and damage better trees. *They should be cut.*

(3) *Trees of the future.* These are vigorous members of the stand, but do not attain up into the main crown canopy. They are of good form and species. Their development should be encouraged by removal of damaging neighbors. They will rarely reach full maturity in the stand unless special reasons necessitate removal of neighboring principal trees. *They should be spared.*

(4) *Useful associate trees.* These are fillers in the stands that help to further natural pruning, force the height-growth and improve the form of their neighbors of Classes 1 and 3. *They should be spared.*

(5) *Indifferent trees* are such as it is difficult to judge in respect to their bearing upon stand development. If they are not needed for soil protection and can be removed at a profit, *cut them.*

The designation " Rational " thinning is also applied to the Danish system above outlined. (See Table XXXVII.)

Thinning from below has considerable standing in Sweden, especially in its heavier applications. The forest research of the country has not yet definitely decided which general method of intermediate cutting is best adapted to yield the greatest volume and money returns under soil, climatic and economic conditions usually at hand. Advocates of selection regeneration naturally look to crown thinning (from above) as a transition step whereby even and near-even aged stands may be converted to an irregular all-aged condition suited to selection management; while clear-cutting proponents tend toward low thinning, in spite of the fact that it accentuates every danger to which even-aged stands are subject.

Assistance thinning (" Hjälpgallring ") is nothing else than cleaning or assistance cutting in young stands.

Sanitation thinning (" Rensningsgallring ") is merely the practice of cutting out dead, dying and hopelessly crippled or worthless trees. It is illustrated best in the treatment given check plots used for comparison in series.

Accretion or light cutting (" Ljushuggning ") is a frequent practice on well managed Swedish forests, particularly toward the end of the rotation. According to Amilon [3–450], it consists in breaking up for all time the continuity of the forest canopy. It reduces the per acre increment of stands, but concentrates this on the choicest boles.

CROWN CLASSES AND METHODS USED ON FOREST RESEARCH SAMPLE-PLOTS [55]

Research in Swedish forestry has always taken special cognizance to thinning and care of stands from the standpoint of treatment to heighten production. The large number of permanent sample-plots established in every part of the country are all models of thoroughness, and care as to details. Data collected from time to time when plots were measured up is all on file in the central office at Stockholm, so far as plots of the State Forest Research Station are concerned. Trees are not only classified and recorded, as is usual for work of this kind, but each plot is mapped and trees located with surprising exactness [58–112]. This is attained by stretching strings to divide each plot into squares approximately eight yards on a side. With a four-yard rod it is easy to locate each tree in these squares.

Crown classes are differentiated in detail, using a special adaptation of the German system of Gustav Kraft. The basis of classification is height, but sub-classes for the character of the crowns are used as follows:

Kraft's Crown-Classes and Modifications Used in Sweden

1.—Trees of the *Dominant Class* form the upper level of the stand canopy.
2.—*Co-dominant Trees* are more than three-fourths as tall as the average dominant individuals and grow under good light conditions usually.
3.—*Trees of Intermediate Crown Level* are more than one-half as tall as average dominants.
4.—*Suppressed Trees* of the forest understory are less than one-half as tall as the dominant trees [26–55 and 58].

When trees in any of the above classes are perfect in shape and development, they are designated merely by the numbers above given, but perfection in the forest is about as rare as in human society, hence the below letters, in addition to the proper number for a tree's canopy position, serve to describe other features of the crown; except the first, which is used alone and independent of crown-canopy levels:

o.—*Over-standards,*—trees at least forty years older than the average dominant individuals and commonly much exceeding them in height and D. B. H.
a.—Trees with crowns developed unsymmetrically and largely limited to one side of the stem.
b.—Thrifty trees of the " Wolf " type with wide crowns of heavy lateral branches, but straight boles.

c.—Very crooked, much branched trees, productive of cordwood and not saw-timber.

d.—Trees of the " Whip " type with very narrow constricted crowns often showing injury due to contact with branches of neighboring trees.

e.—Trees exhibiting injury due to insect or fungus attack of rather serious nature.

f.—Dead trees and those with badly broken crowns, also those partially over-thrown by wind, or snow pressure.

(*Note:*—Some of the above tree types are quite uncommon in certain crown canopy levels.)

Table LXXX covers the most common types of thinning practical in progressive forestry of the Old World. All the prominent forest research institutions have sample-plot studies under way to determine

TABLE LXXX.—TREE-CLASSES AND CROWN TYPES REMOVED IN DIFFERENT GRADES OF THINNING, (SWEDISH FOREST RESEARCH STATION)
Thinning from Below, so-called German System
(Low Thinning,—" Loggallring ")

(*Note:*—All tree-classes listed are to be cut unless parenthetical figures indicate otherwise.)

Tree Classes	Very Light (cleaning)	Light	Heavy	Extra Heavy
0	—	0	0	0
1	—	—	—	1 (2) (some)
1a	—	—	1a (2)	1a (2)
1b	—	—	—	1b (2)
1c	1c (2)	1c (2)	1c (2)	1c (2)
1d	—	—	1d	1d
1e	—	1e	1e	1e
1f	1f	1f	1f	1f
2	—	—	—	2 (2)
2a	—	—	2a (2)	2a (2)
2b	—	—	—	2b (2)
2c	—	2c (2)	2c (2)	2c (2)
2d	—	2d (2)	2d	2d
2e	—	2e	2e	2e
2f	2f	2f	2f	2f
3	—	—	3 (2)	3 (2)
3a	—	—	3a (2)	3a (2)
3b	—	—	3b (2)	3b (2)
3c	—	—	3c (2)	3c (2)
3d	—	3d	3d	3d
3e	—	3e	3e	3e
3f	3f	3f	3f	3f
4	—	4 (1)	4 (1)	4 (1)
4a	—	4a (1)	4a (1)	4a (1)
4b	—	4b (1)	4b (2)	4b (1)
4c	—	4c (1)	4c (1)	4c (1)
4d	—	4d (1)	4d (1)	4d (1)
4e	—	4e	4e	4e
4f	4f	4f	4f	4f

TABLE LXXX.—*(Continued)*

Thinning from Above,—French System
(Crown Thinnings,—"Krongallring")

Tree Classes	Very Light (cleaning)	Light	Heavy	Extra Heavy
0	—	0	0	0
1	—	—	—	1 (4)
1a	—	—	1a (4)	1a
1b	—	1b (4)	1b	1b
1c	—	1c	1c	1c
1d	—	1d	1d	1d
1e	—	1e	1e	1e
1f	1f	1f	1f	1f
2	—	—	—	2 (4)
2a	—	2a (4)	2a	2a
2b	—	2b (4)	2b	2b
2c	—	2c	2c	2c
2d	—	2d	2d	2d
2e	—	2e	2e	2e
2f	2f	2f	2f	2f
3	—	—	—	—
3a	—	—	—	—
3b	—	—	—	—
3c	—	—	—	—
3d	—	3d (4)	3d (4)	3d (4)
3e	—	3e	3e	3e
3f	3f	3f	3f	3f
4	—	— (3)	— (3)	—
4a	—	— (3)	— (3)	—
4b	—	— (3)	— (3)	—
4c	—	— (3)	— (3)	—
4d	—	4d (4)	4d (4)	4d (4)
4e	—	4e	4e	4e
4f	4f	4f	4f	4f

U—Seedlings in the understory. They should be retained under all conditions. *Notes:*—(1)Can be retained if desirable from standpoint of under-growth. (2) Can be retained if needed to maintain an unbroken canopy. (3) Can be removed if to the advantage of understory conditions. (4) Remove only in part.

the most preferable of the following standard methods for each important forest tree species and product.

In making all thinnings, it must be kept in mind that the crown-canopy should not be permanently broken. This is the outstanding difference between *thinnings* and *accretion* or *Interlucation Cutting* as practiced in Sweden.

RESULTS ACHIEVED BY THINNING

In Table LXXXI are given figures which show the results of thinning in Swedish forests and also give an idea of the execution of this work in actual practice from standpoint of effect upon the several crown classes. From the volume basis the tables that follow do not make out such a brilliant case for intermediate cutting, but when the reader notes the number of trees per acre and their dimensions or average contents, it is realized that in the thinned stands all the increment is being concentrated on a few large choice stems, while in untreated stands a somewhat less increment is spread over a great number of small inferior boles [58–108].

TABLE LXXXI.—Effect of Different Types of Thinning

Condition and Treatment	Age (yrs.)	Check Unthinned Area*	Lightly Thinned from Below	Heavy Low-Thinning	Lightly Thinned from Above
		Number of Trees per Acre			
(1) Sample-plots at Storholm, Lycksele Parish, North Sweden					
Original Stand	54	3,589	5,832	3,866	3,897
After Thinning	54	3,282	1,983	1,578	3,340
After Thinning	61	3,282	1,611	1,195	3,038
After Thinning	66	3,193	1,214	829	2,450
% of Original Stand	66	89%	21%	21%	63%
(2) Plots at Isön, Storsjön, North Central Sweden					
Original Stands	52	3,877	2,644	2,433	
After Thinning	52	2,566	1,643	1,287	
After Thinning	59	2,183	1,427	1,063	
After Thinning	64	2,148	1,125(a)	855	
% of Original Stand	64	55%	43%	35%	

*Even the check areas are given a sanitation cutting to remove all seriously diseased and hopelessly weak trees. Such cutting may remove a good many small pines in stagnating stands.

(a) The last thinning in this stand was made from above.

It is but logical that the average tree should be much larger under the practice of thinning from below than when crown thinning is practiced or if stands are untouched. The mere removal of all or nearly all the trees in the lower D. B. H. classes at each return of thinning causes the size of the mean tree to increase rapidly; thus a large apparent increment is added to the actual growth when average tree dimensions are compared. The extent to which real and apparent increment are attained by the usual types of thinning is illustrated in Table LXXXII, covering the same stands and period of years as Table LXXXI. The original mean tree dimensions were for each series very close to those given for the unthinned check plot. Comparing each check plot with itself, it is possible to see about what the actual increment has been in terms of D. B. H. and height. This line of reasoning disregards two errors, but they tend to compensate. The apparent increment as to mean trees is roughly equivalent to the difference between final figures for D. B. H. and height from check plots and from the other respective plots in the same series.

Considering the two series of plots covered by Tables LXXXI and LXXXII as being representative of the gain from thinning in North Sweden, it appears that light low thinning increases absolute volume growth from 4% to 15%, while heavy low thinning causes an increase of 29% to 37%, and light crown thinning about 8%.

It has also been noted that thinning brings some other important advantages in addition to increased increment and better quality of product [57–VI–36]. Better sanitation of the stand and resistance to various factors of damage are typical of these gains from proper intermediate cutting, yet in respect to snow damage and resistance to storm winds, Swedish thinning results have not been uniformly favorable [61–1918–205] and stand somewhat at variance with effects achieved elsewhere. The reason why thinning does not exert such proportionately great influence for good in these boreal forests as it does further south, lies in the prevailing crown form of the trees. The narrow spire-like crowns stand close together and are naturally very symmetrical, while in warmer climates the prevailing wider crowns are very likely to be unsymmetrical and unbalanced in the original stands. When these forests are thinned, better balanced crowns develop and rooting is improved also. When Scandinavian forests are thinned heavily, the mutual ability of trees to support and help each other, which was originally far greater than can be found in coniferous stands further south, is much decreased and deeper rooting is slow or impossible of immediate development because of low soil temperature [64–1926–344].

TABLE LXXXII.—INCREMENT ATTAINED BY VARIOUS THINNING SYSTEMS
(See Table LXXXI.)

Dimension or Condition	Units of Measure	Unthinned Check Area*	Light Thinning from Below	Heavy Thinning from Below	Light Thinning from Above
(1) Plots at Storholm, Lycksele Parish					
Original Av. D. B. H.	in.	2.8	(2.8)	(2.8)	(2.8)
Final Av. D. B. H.	in.	3.1	4.3	4.4	2.9
Original Av. Height	ft.	34.7	(35.)	(35.)	(35.)
Final Av. Height	ft.	41.	45.	46.	43.
Final Av. Volume per Tree	cu. ft.	1.13	2.01	2.22	1.09
Total Inc. in 12 Yrs.	cu. ft.	843.	872.	1,086.	915.
Inc. per A. per Yr.	cu. ft.	70.	73.	91.	76.
Inc. % for Period	%	2.5	2.8	4.9	3.4
(2) Plots at Isön, Storsjön					
Original Av. D. B. H.	in.	3.1	(3.1)	(3.1)	
Final Av. D. B. H.	in.	4.0	5.4	5.5	
Original Height	ft.	33.8	(34.)	(34.)	
Final Av. Height	ft.	42.	45.	47.	
Final Av. Volume per Tree	cu. ft.	1.86	2.89	3.48	
Total Inc. in 12 yrs.	cu. ft.	800.	915.	1.072	
Inc. per A. per Yr.	cu. ft.	67.	76.	89.	
Inc. % for Period	%	1.9	2.2	3.0	

*Figures for inches and feet in parenthesis are estimates calculated from data on check plots of same age and series.

Amilon, after thorough study of the very real danger of snow break in Swedish forests, concludes that thinning does not diminish this danger, but probably tends to even accentuate it, although not to an extent that the practice is inadvisable. He states that crown thinned stands suffer more from snow than stands of the same type thinned from below. Heavily thinned stands suffer worse than lightly treated ones in many instances. Mixing of species, so as to attain two storied and irregular stands, is considered the best step toward prevention of snow and storm damage. It is especially desirable that birch and larch be mixed in along with pine and spruce.

Such experience as the foregoing is the direct antithesis of that in Germany, and demonstrates the importance of considering climatic factors in respect to nearly every phase of forestry. As regards forest conditions in the U. S. A., thinning will probably be highly beneficial toward developing storm resistant stands.

In the management of larch stands, thinning has been an unmixt blessing. Heavy thinning from below is best for trees in this genus. All débris should be burnt or removed if any danger of the larch canker (*Dasyscypha wilkommi*) exists, as its saprophytic stage on tops and branches lying on the forest floor would greatly increase the production of spores. Pruning is also recommended by Schotte as a means to avoidance of canker. Thrifty and vigorous trees have always been most resistant to this disease. Plantations on good soil and those kept growing vigorously by intensive thinning have rarely suffered from canker [54–689].

In summarizing, it is found that heavy thinning is very popular in Sweden. The chief reasons are found in the fact that it means an early return from the forest stand and consequent reduction of the forest investment on a particular area. It also influences the relations between different trees in a stand,—removing the inferior and stimulating the best stems by its effect on stand climate, humus, soil and soil vegetation.

CHAPTER X

LAND DRAINAGE AND ITS RESULTS

In Sweden more than any other country are found large drainage projects for forestry purposes. Many such projects are extensive and well planned with due regard to maintenance of good drainage after it is once attained. This work has been under way in many localities for thirty years or more and now shows results of importance to forestry the world over.

The first forest drainage was doubtless incidental to proposed land clearing, or opening of diversion ditches to eliminate swampiness on lower lying cultivated areas. It was noted in such instances that tree growth responded remarkably. Dwarfed and stunted pine, birch and spruce, that seemed on the verge of death, prematurely aged and decrepit because of stagnant water about their roots, took a new lease of life and after a few years had new thrifty crowns of very different appearance than prior to drainage. Thoughtful and far-sighted land-owners began to take advantage of this response to drainage and turn their attention to ditching (*Dikning*) as a means of redeeming for production the vast areas of bog and marsh land that abound in nearly every section of the country but are especially prominent northward.

BOG AND MARSH AREAS IN NORTH AND SOUTH SWEDEN

In 1925 is was estimated that 30% of all Norrland (the area north of the Dal River Valley) was bog, marsh or "drowned forests" (*Försumpade skogar*). Oxholm says [45–17] that more than 40% of the land area is bog and marsh in some sections. In 1912 Dr. Hj. von Feilitzen published a careful estimate of the area of peat bogs and swamps by provinces. For Norrland he put the undrained area at 8,378,000 acres, or 15%, while the rest of Sweden has 4,304,000 acres, or 9½%, of bogs and marsh. Even adding the total water areas in the first of these two regions we get a figure somewhat too low, but for South Sweden this early estimate is quite accurate.

Östlin estimates 17% of Norrland [44] to be bog, which agrees closely with the value arrived at (16.7%) by the National Forest Inventory for the middle and southern provinces of this great northern region [70–11/1926–537]. Norrbotten province has a vast area with a probably higher ratio of bog and will possibly bring the bog area for all Norrland as high as 20%. This is only two-thirds of what well informed foresters believed prior to the general inventory work recently executed. Yet this signifies that upwards of 12,000,000 acres of land are rendered unproductive here due to poor drainage.

Adding the bog area of South Sweden, it is seen that as late as 1910 over 16,000,000 acres of Sweden was too wet for forestry or agriculture and millions of acres had certainly been reclaimed prior to that date.

From the foregoing it is seen that the total undrained area of Sweden is extensive indeed, and certainly important enough to warrant the attention of the best statesmen and engineers. Realization of this fact has been dawning upon the popular mind, and since the World War it has been the policy of the government to expend funds upon this work wherever it promises best economic returns. By pushing the projects at times when unemployment is rife and business on the decline, drainage work has exerted a certain stabilizing influence upon social and industrial conditions, tho likely at some sacrifice of efficiency.

Among the countries of Europe probably only Russia and Finland possess a greater swamp-land area than Sweden. Relatively, only Finland exceeds Sweden in this respect. The recent forest inventory shows 35.7% of all Finland to be poorly drained by nature [10–9–1925–English–12]. This means an area of over 28,000,000 acres. For northern Finland 44% is in need of artificial drainage, while for the southern half of the country about 25% is too wet for agriculture or good forestry until the excess water is led off.

The data from the Swedish National Forest Inventory gives most reliable information upon the possibilities these great swamp areas hold from the standpoint of forestry. In the recently investigated northern provinces, drainage experts consider 31½% of the swamp area as well adapted to reclamation, 29% is capable of drainage at moderate cost, but promises only mediocre or slow returns from the work, while 39½% is ill-adapted or impossible of drainage. Naturally, in Central and South Sweden the proportion of lands capable of profitable reclamation is much higher.

CLIMATIC EFFECTS OF BOG DRAINAGE

Judging by observation and available literature [3–162 and 273], drainage work in Sweden has never resulted detrimentally to forests on land adjacent to the areas treated, as is frequently said to be the case in Germany. Injury to forests in this way would be due to lowering of the ground water level, with consequent failure of capillarity to bring up to the tree roots as much moisture as they had been accustomed to prior to drainage operations. Recent studies show that the importance of capillarity in raising water up to the root zone of plants has been largely over-estimated, even as concerns agricultural lands. In forests on moraine peat and sand soils, capillarity is probably utterly negligible. Hesselman has shown that the moisture content of the upper foot of mineral soil is almost universally higher than between this level and the water table. This being the case, it is easy to see why forest owners in Scandinavia and nearly everywhere else need fear no ill results from this work.

The effect of drainage on frost danger and length of the growing season is interesting. It is an opinion universally held in Sweden that drainage of bogs and marshes lessens the danger of damage to vegetation by late spring and early autumn frosts. The scientific facts do not support such an opinion in so far as direct results go. Water in any locality tends toward equability of temperature conditions, hence to prevent frosts after growth has once started in spring and delay the incidence of frost in fall. But two facts probably operate to justify the prevalent faith in drainage as a means toward amelioration of climate; (1) drainage ditches usually afford a straight, smooth, and evenly sloping, though probably narrow channel whereby cold and stagnant air is led out of the basin like depressions where bogs commonly occur and damaging frosts are most frequent. In this way an air circulation is secured which often prevents the temperature from falling to freezing point during calm nights when radiation is rapid. (2) After land is drained it warms up much earlier in spring, so it is not unusual for drainage of an area to expedite vegetative activity by two weeks or more. Vegetation probably develops more rapidly on the dark colored soils after drainage because of higher temperatures attained, than would be the case on such an area when it was moss covered and wet, with evaporation exerting a constant cooling influence. This permits completion of growth and maturity of succulent tissues before autumn frosts occur.

Peat soils typical of Swedish bogs are very slow in responding to ditching, due to their hygroscopicity and general fine texture. Amilon states that where forest planting is purposed, three to six years should elapse in South Sweden and four to ten years in Norrland after ditching before the afforestation work is executed. This seems like an unusually long period, but it is explained in part by the fact that for forestry use, soils are never so thoroughly drained as for agriculture. Ditches are spaced wide and often only tap the apparent sources of the water that is in general responsible for swampiness. It is sufficient in forestry with most species if they can be well established on a superficially drained substratum, as by their own transpiration they exert a very real power toward dessication of the soil, especially in regions with precipitation as low as has Sweden.

THE RISING WATER-TABLE ("FÖRSUMPNING"),—CAUSES, RESULTS AND REMEDIES

It has been a firmly held tradition over Central and North Sweden for many years that the water table is rapidly rising over large areas. Inferior, slow growing and sickly forest stands on wet sites are commonly ascribed to the fact that the soil has become progressively wetter, until the trees can scarcely exist. The prevention of this drowning out of adjacent good forests is one of the chief arguments often advanced to justify bog drainage work. It now appears from the research of Malmström [61–1923–138 *et seq.*] that this spreading of bogs and rise of the ground water is exceedingly slow, and not at all to be feared under ordinary conditions. It was shown by the non-occurrence of pollen grains of certain tree species that the bog area of large localities in North Sweden had changed but little in the aggregate in course of thousands of years.

Blocking up of stream channels by accumulated vegetable residues, especially of the sphagnum mosses, naturally may affect the water table above the obstruction. Decreased transpiration, due to lumbering off of the forest cover or its lack of thrift for any reason, may cause an area to be wetter than it was when a thrifty and heavy stand of trees was constantly pumping water back into the atmosphere. Cyclic climatic variations also cause change in ground water conditions, but all, or nearly all such stimuli to bog development are quite ephemeral.

Stream cleansing has been found very effective toward improvement of forest growth over large areas. In Canada, too, operations of this kind have been found just as beneficial to black spruce as is this work in Scandinavian forests.

Good silviculture, which maintains a constant thrifty unevenaged forest cover, undoubtedly exerts a strong influence toward holding undesirable vegetation in check and transpires quantities of water that might otherwise drain away very slowly and prove detrimental by exclusion of oxygen from the tree roots [58–45]. Partial cutting of forest stands in such wise as to remove all the best full crowned trees and leave only a " scrap-woods " of defective hypermature and slow-growing young stock, has probably often resulted in at least temporary and possibly permanent raising of the water-table. Strong insolation of the soil after diameter limit cutting (" Dimensionshuggning ") stimulates heath shrubs and other plants of xerophytic character. Such species transpire but little water, yet by hindering decomposition they hold in check the growth of such trees as may be present, while at the same time preventing reproduction and collaborating with sphagnum mosses to choke up natural drainage courses [31–25].

Birch is a tree that should be encouraged upon areas where drainage work has been done or is needed. In Norway, Mrs. Resvoll-Holmsen has demonstrated that leaves from birch hinder or even inhibit development of sphagnum, and possibly also other pronounced calcofuge species. The effect is due to the high lime content of birch litter. Whether extreme claims of this sort can be accepted as generally applicable may be doubted, but it is certain that the birch has been a splendid pioneer upon lands drained heretofore. It improves the soil and dissipates water at a rate equalled by no other tree.

THE ECOLOGY OF BOGS AND THEIR PRODUCTIVITY

The character of a bog is in part controlled by the topography of the solid earth beneath it and the course of events incident to its development from a glacial lake, or at the other extreme, from poorly drained forest on flat or slightly rolling plateau or bottom lands. A still more important factor in the ecology of a bog is the chemical content and amount of water that flows into it, which depends upon the rocks, soils and area of the drainage basin. These circumstances determine within narrow limits the species of plants and lowly life forms which will flourish and contribute their remains to the peat or peaty soil. It is largely the quality of the peat or turf that must be considered in estimating the returns that may be attained by drainage.

Years of experience in drainage for forestry purposes have yielded facts that are well worth the attention of land-owners in the north-eastern U. S. and Canada. There is no doubt that we have large areas in America that approach closely the glacial bogs and marshes of the Baltic region. Certain types have been proven worthless or nearly so for forest production. In this class are all pure sphagnum bogs where the mineral soils lie more than sixteen to twenty inches below the surface of the peat.

The white mosses (*Sphagnum* sp.) gives rise, by reason of the plant food poverty of their residues, to the poorest type of peat soil. When mixt with the remains of higher plants, such as grasses, rushes (*Carices*) and débris of birches, or even spruce, the sphagnum peat may support good growth after drainage. Its quality, and in general that of all turf and peat soils, is in almost direct ratio with the rate of decomposition.

The "Bear Mosses" (*Polytrichum* sp.) form a poor and slowly decomposed type of peat, but it is relatively unimportant as to occurrence under bog conditions.

"Brown Mosses" (*Amblystegium* sp.) yield very favorable peat. They usually occur intermixt with sedges, horse-tails (*Equisetum* sp.) and similar turf builders. These mosses indicate presence of lime in the water to a desirable extent, while the thrift of the white mosses is in inverse ratio to the lime content.

The sedges (*Carices*) form good turf, while Cotton Grass (*Eriophorum* sp.) give rise to or indicate poverty of mineral plant food elements Twig grass (*Cladium mariscus*) requires considerable warmth and lime. It builds turf of high quality.

Presence of broadleaf herbs and birch, hazel or alder indicate good productive possibility. Willows are not quite so good in significance, spruce is fair, heath shrubs are in general bad, as is also dwarfed pines. Intelligent interpretation of the vegetation upon a bog gives probably a better index to productivity than analyses of peat or instrumental studies; altho the latter are often very helpful to the economic execution of a project.

Diatoms with siliceous skeletons contribute nothing of value to the constitution of peat soils; however, if they carry lime the soil quality will be improved by their presence.

PRESENT STATUS OF FOREST DRAINAGE IN SWEDEN WITH FUTURE POSSIBILITIES

Failure to realize all the rosy benefits pictured by draining enthusiasts has resulted in disappointment occasionally. Some skeptics speak out from time to time and belittle the substantial benefits actually attained. These facts have led recently to careful research upon several areas with the aim of definitely assessing the gains or losses from such work [32 and 64–Vol. II–1927–273]. The reports by Lundh and Borjeson here referred to, are models of their kind and should forever silence the critics who choose to close their eyes to the obvious success of well planned drainage on many areas.

The persistence of numerous forest owning corporations in this line of activity is a strong testimonial that the work shows rich promise of satisfactory financial returns. The large body of trained foresters employed in the national service, as well as in the several provinces, have never faltered in their faith in drainage; altho at times they lamented the lack of foresight and efficiency that characterized certain projects.

There has also been an occasional voice raised in protest against projects that drained large lakes or bogs, whose water exerted a stabilizing effect upon stream flow. This effect of drainage for forestry purposes can readily be over-estimated, and so far as Scandinavia is concerned merits only passing notice. The peat soils still persist under forest cover and act very effectively as retainers of snow and ice in spring, and water at all times. They also transpire more moisture into the air than would evaporate from an open water surface or a moss-covered area. Probably being double or treble as effective in this respect [31–16 to 20] as an equal area of open water would be. The activity of mosses, especially sphagnum, in regard to transpiration is most interesting and quite unlike higher plants. Conduction of water and its delivery to the air is purely mechanical. In other words, moss functions just about as dead material would. When there is abundant water in its lower layers, or the substratum beneath if this does not lie too deep, the mosses by capillarity and evaporation give off to the air as much or more water than would vascular plants, but as soon as the moisture content of the upper soil becomes moderate or low, then relatively little water is given off. From this it would be logical to suppose that afforestation of bogs tends toward equability of climate with greater frequence of light

TABLE LXXXIII.—Stem Analysis of 60-Yrs. Tree Grown on Area Ditched in 1905

Year	Age	D. B. H.	C. A. I. for Preceding 5 Yrs.—D. B. H. (in.)	Height (ft.)	C. A. I. for Preceding 5 Yrs.—Ht. (ft.)	Volume (cu. ft.)
1895	30	1.22		10.01		.06
1900	35	1.61	.08	11.65	.33	.13
1905	40	1.95	.07	12.96	.26	.19
1910	45	2.34	.08	14.11	.23	.26
1915	50	3.58	.25	17.39	.66	.66
1920	55	4.09	.10	24.77	1.48	1.13
1925	60	4.84	.15	28.22	.69	2.01

summer showers, but possibly a little less total run off and slightly higher peak stream-flow in periods of excessive precipitation.

The recent studies referred to [64–1927–301] show many instances where forest drainage has increased the current annual increment of stands from 250% to over 400% (from fourteen cubic feet per acre per year to seventy cubic feet or more), and in case of certain utter waste areas an annual increment of forty-eight cubic feet per acre has been attained within twenty years after ditching. Borjeson cites a stand at Robertfors that was drained in 1862 and was then absolute waste marsh, which in 1925 showed ideal forest conditions and ability to grow timber at the rate of seventy-five cubic feet per acre per year (M. A. I.).

TABLE LXXXIV.—Results from Forest Drainage [32–315 to 345]

Plot No.	Description of Area before Drainage—Site Quality (after Jonson)	Yield per A. per Yr. (cu. ft.)	Site Quality in 1923 and Yield per A. per Yr. (cu. ft.)	Increase in Value by Drainage ($ per A.)
1	Brushy Marsh	0	III—86	19.76
2	Drowned Forest—VII	26	III—86	28.73
3	Drowned Forest—V	49	II—114	49.57
4	Drowned Forest—V	49	II—114	49.57
5	Mossy Sedge Bog—	0	III—86	14.47
6	Drowned Forest—V	49	III—86	15.88
7	Drowned Forest—V	49	III—86	15.88
8	Brush-grown Bog—	0	IV—64	8.64
9	Drowned Forest—V	49	III—86	27.00
10	Drowned Forest—VI	36	III—86	27.97
11	Sedge Bog—	0	III—86	14.47
12	Drowned Forest—V	49	II—114	35.64

Table LXXXIII shows the reaction of an individual pine tree from the Robertfors locality on a later drained area. The delayed effect is typical.

The studies of Lundh at Bjurfors are very thorogoing and are submitted in summary as Table LXXXIV. Here is demonstrated in actual figures the monetary gain attainable by Swedish land-owners thru forest drainage work. All data are from the crown forest described in Chapter V and used by the Royal College of Forestry as a summer study and demonstration unit. Something over eighty miles of new ditches were put in on this forest between 1897 and 1920.

The author points out that the calculated increase in land values due to greater production since drainage deals with a locality where economic conditions and accessibility are probably below the average for Sweden generally. It is therefore fair to assume that the results enumerated in the appended table are conservative and can be used to demonstrate the possible economic benefits of such work thruout Middle and South Sweden generally.

In the two typical provinces of Smoland and Kopparbergs it is estimated by Lundh that nearly 500,000 acres of easily drained wet lands of good quality await attention. In addition, more than double this area offers considerable promise. This signifies that with a gain of $30.00 per acre on the best lands and $15.00 on the poorer ones, it is possible to increase the forest wealth of these two relatively small provinces to the extent of over $13,000,000. This, however, takes no consideration of costs involved, yet it is not likely this would total but a fraction of the above sum. Moreover, these lands lie in a region where the lumber and pulp industries have heavy fixed investments. This capital will be endangered for lack of raw material in a few decades, hence every acre of forest won to production will be of great national economic advantage.

Swedish corporations have been expending about $250,000 annually upon drainage work since the dawn of the century. This suffices to dig about 1,340 miles of ditch and shows that hhis group of landowners alone have dug enough ditch to girdle the earth once and half again. One single corporation ("Mo-Domsjö") had drained 125,000 acres of their forest prior to 1917 and had enough ditches to reach half way around the earth. This concern, however, was a pioneer in this field and started ditching in 1887.

The Provincial Forest Protection Boards have also been active in land drainage. Between 1905 and 1925 they supervised work on smaller properties involving nearly 40,000 miles of ditches as a total.

It is therefore obvious that this phase of forestry has come to stay in Sweden, and land drainage will not cease until nearly every bog and marsh worth while has been made productive. In this respect, Sweden and Finland point the way for the glaciated forest regions of North America.

CHAPTER XI

SAND DUNE CONTROL AND HEATH LAND PLANTING

Both the above lines of forestry activity are better developed in Denmark than in Sweden. In fact, the former country is a model for the latter in most respects, where intensity rather than extent of work is in question.

SAND DUNE AREAS IN SWEDEN

For centuries there has been trouble with drifting sand along the south coast of the country. The town of Falsterbo has been buried a number of times and in all about [74–374] 2,500 acres of dunes occur in the province of Halland. Further north the coast shows limited dune areas, as is also the case on the larger Baltic islands of Öland and Gottland. On the latter island a lighthouse has been defended with difficulty against encroaching sand. In a number of places forests have been engulfed by moving dunes, some of which travel with a speed of ten to twenty-five feet per year. Inland dunes are reported from the province of Smoland, but are of minor consequence.

While these dunes are very small in extent as contrasted with those found further south in Europe, *e. g.,* adjoining the Bay of Biscay, they are still of economic interest, due to their northern location and successful treatment. Especially in regard to the numerous tree species that were used experimentally in afforesting these sites.

METHODS AND SPECIES USED

Even prior to 1800 the Swedish government took some measures to fix such dunes as threatened damage. Fencing with stakes and brush was found effective toward checking the movement of sand. Grasses of the genera *Elymus, Carex* and *Arundo* were planted just as in the classic French examples. Heath litter, pine brush, moss and sea-weed, as well as clay and marl, were all found helpful in holding the sand until a living cover could be established on its surface. European mountain pine (*Pinus montana* forms) has been found about the best tree for holding sand in place and building it up in fertility, so more exacting species may later be introduced. The common pine (*P. sylvestris*), as well as Corsican and maritime pine (*P. laricio* and *P. pinaster*) have failed, usually due to wind and cold. Only in sheltered locations do these trees occasionally show thrift. The success of an alpine tree on these sands under practically sea-level conditions is indeed surprising and illustrates well the adaptability, vitality and aggressiveness of the species.

A complete and even stand with prohibition of grazing and traffic or travel is very important in afforesting dunes. The cost of the work is considerable. Wahlgren cites [74–379] that work done in 1874 to 1888 cost about $28.00 per acre. Norway Spruce has only made successful growth on the dunes when sheltered and favored by unusual moisture or other advantages. White spruce (*Picea canadensis*) has thriven well and is often used to form a protective belt behind which other more tender and exacting crops are grown. Banks pine (*Pinus banksiana*) and Lodgepole pine (*P. murrayana*) make good growth, due to modesty in soil requirements.

Sitka spruce is quite resistant to injury by salt sea breezes and thrives wherever there exists a fair degree of fertility. Nordmanns, grand and noble firs (*Abies nordmanniana, grandis* and *nobilis*) have been planted experimentally in a limited way and show promise on better sites.

The native white birch and gray alder (*Alnus incana*) have grown best upon the dune areas where hardwood trees were tried. The various cottonwoods and poplars (*Populus* sp.) which have been found useful for this kind of planting in America have failed almost utterly in Sweden and Denmark. The single-stemmed mountain pine or Pyrenean pine (*P. montana gallica*) is all in all the best tree yet tested thoroly. These soils are poor in humus and nitrogen, and this tree with its heavy needle fall improves the soil very considerably, while at the same time producing wood that supplies a multitude of homely uses. Dune areas often show swampiness from the choking of natural water courses by drifting sand, or the blowing away of the soil in dry seasons down to the level of the water table. In either case, willows and alders (*A. incana* and *glutinosa*) have been found best for initial forest growth. Such areas are commonly coppiced on a short rotation and tend to so improve and even drain the soil that birch, aspen and spruce can later come in.

The high fire risk presented by sand-dune forests has been illustrated in Sweden and is guarded against by carefully planned nets of trails and fire-breaks. Wahlgren [74–381] relates the occurrence of a devastating fire that destroyed 2,600 acres of planted woods on the sand fields of the isle of Gottland.

The management of dune forests in Sweden is quite conventional. The sheltering margin of all stands is kept as dense as possible, restricting openings to a minimum by selection cutting. Back of this protective marginal belt thinnings are made as economic conditions permit, but are usually of the lighter grades. Reproduction is limited to small areas, but may even proceed by clearcutting. Shelterwood methods and seed-trees accompanied by planting are most often seen in Denmark, where the earliest Scandinavian dune afforestation work was done. Grazing is universally prohibited on these areas, since a maximum of vegetation is always desirable, and tramping of sharp-hoofed animals is capable of giving the wind a start so that " blow-outs " may originate at exposed points.

HEATH AREAS IN SWEDEN

Very considerable tracts of waste land are characteristic of all the countries of Northwest Europe. The British Isles, Holland, Germany, Finland and Scandinavia have sites devoid of productive forest, or any forest growth whatever, which present very real difficulties when afforestation is attempted. Such sites show a typical vegetative cover usually built around the heather,—" The bonnie, blooming heather " of poets,—(*Calluna vulgaris*), or similar low shrubs of the family *Ericaceæ*. The soils are acid in reaction and leached out so far as soluble mineral fertility is concerned, since they are open and sandy, as a rule, in respect to upper layers. Vegetable débris tends to accumulate on the surface, but has in times past been destroyed annually or at short intervals by fires,—generally set with the object of improving grazing conditions. It is probable that nearly all these vast heath areas at one time supported forest, of beech or oak composition in most instances, but recurrent frequent fires thru centuries reduced them to their present status. It is often a matter of record and relics also prove the existence of thriving towns in the midst of what are now barren heaths. The disappearance of civilization from such localities is often ascribed to the " Black Death," some terrible and general conflagration or wars and commotions with attendant pestilence or famine. Yet it is doubtful whether such explanations are ever adequate. It is more probable that the soils were not of truly agricultural quality, and society had to depend largely on grazing and forest products. When, by abuse and greed, the forest and herbage deteriorated or largely disappeared, while the soil decreased in fertility from the standpoint of cultivation, repopulation after decimation from any cause was necessarily slow. In fact, any inhabitants that remained would be inclined to migrate to nearby better localities that had suffered similar depopulation.

Most European heaths are located under decidedly maritime climatic conditions. Whether this is due to some effect of humidity upon the competition of the vegetative forms and associations concerned, whether it is from the effect of salt in the air, which is admittedly unfavorable to most trees, or whether the sandy soils that tend to support heath vegetation owe their origin to the sea, has never yet been definitely determined. Likely all these factors play a rôle in the origin and continuance of the heath lands. Forest planters ascribe many failures to (1) extreme acidity of the soil and an almost complete absence of calcium therein, which causes planted trees to grow very slowly and therefore succumb readily to the (2) strenuous competition of the very persistent heath plants in both earth and air, since they endure acidity and grow well where lime is almost entirely lacking.

In the eastern U. S., especially in New Jersey, and on the mountains in South and Central Pennsylvania, there are vast extents of land that support an acid loving vegetation, mostly of *Ericaceæ* forms, and which exhibit degenerated forest conditions. Regeneration is difficult on these areas and wood increment is low. There is a tendency for débris to accumulate on the forest floor, and leaching has made the upper mineral soil almost devoid of soluble plant food elements. Scrub oak (*Q. ilicifolia*), scarlet oak, blueberries (*Vacinium sp.*), huckleberries (*Gaylussacia*), sweet fern and other myrtles (*Myrica sp.*), with laurel (*Kalmia sp.*) and pitch pine (*P. rigida*) here and there constitute the typical growth. The establishment of a desirable, complete and highly productive forest cover upon such sites as these is almost impossible unless prohibitive sums of money are spent,—speaking from the point of forest finance. It is therefore submitted that the heath planting work so well done in Denmark, South Sweden, North Germany, Holland and to a less extent or more recently elsewhere, may be studied to good advantage by American foresters who may be concerned with comparable sites in the New World.

In Sweden, Finland and certain localities in Germany are found extensive tracts of " Pine Heaths." These areas often exhibit fairly satisfactory forest conditions and are not to be confused with the nearly or quite barren areas hereinafter discussed. Most of the older Scotch pine stands in North Europe, where the species occurs almost absolutely pure, occupy sites that can be truly classed as " Pine Heath."

The area of Swedish heaths has been estimated as high as 1,500,000 acres, but this figure was probably ridiculous, even in terms of the eighteenth century,—for it must be recognized that nature made considerable progress toward reforestation of the more favorable heath tracts wherever seed trees were present and popular enlightenment discountenanced annual burning over of waste lands. Agitation for forestation of both sand dunes and barren heaths is no new or transient thing in Sweden. Amilon records [3–537] that the crown and parliament began to appropriate money to the first cause as early as 1720, and that from 1740 to 1787 an organized and consistently financed effort was made to afforest both dunes and heath areas. Results were apparently quite disappointing, and probably misdirected; and at least to judge by the governmental reports on the subject. One citation is to the effect that a " barrel and a half of gold was spent in vain, except that the officials directing the work made a comfortable living thereby and kept a careful record of expenditures, altho the honesty of these latter could never be verified." From all of which we may deduce that honesty and earnestness on the part of public employees has considerably improved in course of two centuries, and further that we have no weighty cause to be discouraged when knotty forestry problems still resist solution after a decade or two of poorly sustained attack upon them.

The most reliable estimate of the heath land area of Sweden was that made by the Forest Research Station in 1913. At that time 400,000 acres were practically treeless and 50,000 acres supported scattered trees or broken forest stands,—exclusive of sites too poor or wet to support a forest. These figures show that there existed a fertile and extensive field for forest planting on these tracts. It was so well appreciated by land-owners of the country that reports in 1924 showed about 112,000 acres of this type of site had been reforested during the decade, while 50,000 acres had been brought under forest during the seven years from 1907 to 1913 [26–95]. Wahlgren states that by 1923 the area of treeless heaths was reduced to 200,000 acres, which illustrates well how effectively modern forestry solves problems that utterly confounded scientists and land holders of a century ago. It also proves the efficiency of the organization that promoted and carried out this huge afforestation program. We must remember that, with the close spacing required for planting up these sites, the afforestation of 200,000 acres in about fifteen years meant growing and setting in their permanent places more than 400,000,000 trees. Many American states with a population near, or in excess of that of Sweden, and far greater wealth, procrastinate and falter when confronted by reforestation problems of less proportions than these grey old barrens that were characteristic of Southwest Sweden since Viking days.

The two organizations that have been the motive force behind heath forestation work are the Forest Protection Boards, which function in each province and have been heretofore described, and the " Forest Society " (Skogssällskapet) ; a coöperative union of private individuals, local societies interested in rural improvement, and local units of government. It was organized in 1912 under a royal charter and concerned itself for some years only with forestry and allied problems in the five southwestern provinces. By 1919, however, its range of usefulness had been extended to fourteen of the southern provinces. Its great field has been those lands held communally, owned by some unit of government, quasi-public organization or trust.

The provincial boards were very effective in dealing with private land holders, especially farmers who owned woodlots and waste land, and coöperate at all times with the Forestry Society, but this latter organization attacks the hardest problems of forestation, where almost endless red-tape must be untangled before action can be taken upon property in need of attention.

The several provincial forest protection boards (skogsvordsstyrelserna) work under somewhat differing by-laws or regulations, yet as regards reforestation of the heath areas, it may be said in general that they have supplied free seed and planting stock to land owners with *gratis* supervision of the work done and a greater or less contribution toward the labor cost. In addition, where drainage has been necessary, as is often true in the lower lying areas of the rolling heaths, drainage plans are drawn up free of charge and a contribution of funds, usually up to half the estimated cost of the work, is made. This is certainly liberal almost to the extent of paternalism, but it must be remembered that a great portion of these heaths is communal or public property and much of the remainder is held by charitable or semi-public institutions, with relatively very little in strictly private ownership, and this for the most part small areas in the hands of small farmers. Where lands have been denuded or rendered barren by abuse since 1905, when the forest protection law went into force, the boards compel reforestation unless the areas are being adapted to a higher use than forestry, and in this case they merely supply planting material at cost.

The Forest Society of Sweden is modeled closely along lines of the Danish Heath Society (Hedesällskabet) and the Dutch Heath Association [42 and 48–14]. Its supervision in 1923 extended over all the areas listed in Table LXXXV, totalling more than 80,000 acres of plantations.

TABLE LXXXV.—PUBLIC OWNED FORESTS PLANTED ON HEATH-LANDS UNDER SUPERVISION OF THE FOREST SOCIETY

Province	Number of Forest Properties by Types of Ownership				
	County	County and Town (coöperative)	Other Communal Units	Totals	
				(no.)	(acres)
Malmöhus	1			1	4,868
Blekinge		3	1	4	2,792
Kalmar	2	4	1	7	10,230
Kronobergs	1	9	2	12	10,872
Hallands	1	10		11	8,896
Jönköping	1	2	1	4	4,448
Älvsborgs	1	10	1	12	6,499
Göteborg and Bohus		7	3	10	17,346
Östergötland			1	1	890
Södermanland		12		12	6,178
Stockholm			2	2	6,103
Uppsala			1	1	939
Totals	7	57	13	77	80,061

Both Norway and Denmark have extensive heath areas and are engaged in afforesting them as rapidly as circumstances permit. In the latter country the work has progressed and prospered even more than in Sweden, while in Norway it is somewhat more backward. Work on Danish heathlands dates back centuries. Agricultural use rather than forestry was the objective originally in view, as a rule. Success was rare indeed, and as late as 1860 the wide and dismal areas typical of North and West Denmark were considered practically irredeemable. In 1866, however, the "Heath Society" was organized and attacked the problem anew. With the aid of government subsidy and after careful study of work attempted and executed in North Germany, this society started a program that has worked miracles upon what were likely the most stubborn heathlands in the world. The methods used have become a model to surrounding lands, and results obtained are an inspiration to progressive people everywhere. It has often been stated and is literally true, that the Danish Heath Society, since its foundation, has won as much soil back to production as Prussia took from Denmark at the conclusion of her reprehensible war upon this peaceable country.

METHODS USED IN HEATH AFFORESTATION

In Sweden one probably meets greater variety in heath forestation technique than in Denmark, even if this latter land is the leader; for it is never characteristic of Swedes to follow blindly. Danish methods have also been standardized in course of years, and deal with more uniform topographic and soil conditions than are found in Sweden. Treatment of heath soils with marl before planting trees upon them is rarely resorted to in Sweden, but is very common in Denmark. In the latter land much of the better quality heath areas are prepared for agricultural use, while in Sweden this is very seldom the case.

The Danish Heath Society operates a number of marl pits, usually in large part with convict labor. They own and use a considerable mileage of readily moved narrow-gauge railroad for hauling marl from their pits out onto heath tracts under improvement.

Swedish heaths differ from those of Germany and Denmark in rarely showing hard-pan subsoil as is typical there and often an almost insuperable obstacle to forest thrift.

Heaths have been grouped in the following way for purposes of study and forestation:

1. Pure heathland without indicator plants of importance.
2. Heaths with typical lichen soil cover.
3. Heaths with mossy soil cover.
    (a) Mossy heaths with scattered junipers.
    (b) Mossy heaths without junipers.
4. Boggy heaths.
    (a) With scattered growth of junipers.
    (b) With lichen soil cover but no bracken fern.
    (c) With mossy soil cover and bracken fern.

Those heath types showing growth of junipers (*J. communis*) and bracken (*Pteris aquilina*) are most favorable for reclamation. Even hardwoods make good development when once established on them. The pure heath areas are most unpromising and with those of intermediate quality are best adapted to pine forest.

The establishment of pure Norway Spruce stands has very often been the aim both in Denmark and Sweden. This has been deprecated by Dr. Hesselman and numerous other foresters, in spite of the splendid increment many such stands are making (See Table XXXI),—at times as much as 160 to 170 cubic feet per acre and year. In the long run it is deemed wise that some hardwoods, preferable beech and birch, or even oak, should be intermixt with the conifers that are planted on these meager sites. Only in this way is it possible to build up their fertility upon a stable basis and render the problems of reproduction easier of solution in the future. The insect pests that already thrive so exceedingly in pure spruce plantings in several localities of South Sweden are an eloquent voice warning of the ills that are certain to beset extensive and near-even-aged forest plantings.

Heath planting has made use of about the same species as are given for sand dunes, but experience narrows the recommendable list down to some three or four conifers and about as many hardwood species. A sheltering belt or mantle of some hardy and aggressive conifer with dense foliage should protect plantations toward the south, west and east also, if possible. European mountain pine and white spruce have proven best for this marginal growth, but birch can be used, especially if the belts are made about 100 feet wide or wider.

The planting itself has usually consisted of two rows of Norway spruce alternating with one row of mountain pine. In this way each spruce tree has its roots in contact on one side with the soil occupied by the pine, and this sturdy tree with thick dark foliage is the rugged and gnarled pioneer that makes conquest of the heath areas possible.

It was long supposed that the pine was necessary to the spruce here because it supported organisms upon its roots or in proximity thereto which could fix atmospheric nitrogen in the soil where it was available to spruce or other intermixt species. This idea was likely fallacious, but yet the effect attained was the same, since this pine by reason of its vigorous growing root-system penetrates, loosens and aerates the compact soil, making existence and action of nitrifying and other beneficial bacteria and higher life forms possible. It feeds and shelters desirable soil organisms, as well as its more tender tree associates, by virtue of the heavy leaf litter it deposits. The pine is usually cut off when fifteen to twenty years old and the area remains thereafter as pure spruce. The pine is not, as a rule, all removed at once, but as thinnings over a rather short period. The wood is utilized for fuel and posts on better sites, but where the soil is most difficult and the many-boled form (*P. montana uncinata*) of pine has been planted, the whole tree is allowed to lie on the ground for shelter and humus, being purely an investment for the benefit of the spruce that remains and a means to reclamation of the site, from the insidious encroachment of the heather, which is ever ready to take advantage of light and bare soil to regain the terrain man strives to win from it.

The single-stemmed form of mountain pine (*P. montana var. gallica*) is, all in all, the best tree observed by the author on the less favorable of these sites. It has been planted pure on some areas in Denmark, and gives an unmistakable impression of thrift and vigor. When mixt with spruce it will compete in height growth for thirty to forty years upon these rather adverse soils.

The first commandment with all heath planting is to add humus to the soil in quantity and of favorable quality. With this idea in mind the brush from thinnings is carefully scattered where it will do the most good. In some instances one sees litter and débris being marketed from heath plantings in Denmark, but such practices are strongly discountenanced by foresters.

Wahlgren [74–386] advises European larch of Scotch origin for planting upon better heath areas, but emphatically warns against attempting to grow other forms of larch on these sites. This is a strong testimonial as to the fixation and inheritance of acquired characteristics, since the Scotch variety was developed in course of a few centuries by selection and cultivation upon heath areas in Scotland, and had originally no better adaptation to such sites than the other larch races exhibit today.

The first step in afforestation of the most adverse heath is to get rid of the heather. This is not needful where the plants stand sparse or are quite short, yet is in general advisable. The methods of eliminating it are (1) mowing with a scythe, (2) digging or pulling it up, and (3) burning over the area. Mowing results in vigorous sprouting and is of only temporary benefit to trees that may later be planted or seeded. Burning has the same deficiency unless the earth is very dry and the peaty soil is consumed to the extent of killing much of the heather. This is helpful on better sites, but on poor thin soils it liberates nitrogen and destroys organic matter badly needed in the soil. Uprooting and cultivation is the best treatment preparatory to planting, and is not excessively expensive when executed at a time when the soil is still loose and moist in spring, or if limited to a small area around the points where trees or seeds are to be planted.

In Denmark it is not unusual for heath areas to be broken up and plowed to a depth of ten inches, then lie to fallow a year or two and be planted after a second somewhat shallower plowing or superficial cultivation. In Sweden, the heavy expense of such soil preparation, often mounting up to $30.00 per acre, is pointed out, but it is probably an absolute necessity upon extreme sites. It has resulted in successful stand establishment upon sites so poor and exposed that European white oak trees more than 200 years old had attained a height of less than ten feet and illustrating " scrub oak " conditions at its worst. It is believed that scarifying and cultivation of our heath-like soils in America is well worthy of experimental effort from a silvicultural standpoint.

Anton Smitt, a Norwegian forest research worker, has recently published one of the best comments upon Swedish heath forests such as we have discussed [70–5/1928–227]. He considers the heaths of South Sweden of far more recent origin than those in Denmark and Norway, hence of higher inherent productive capacity and easier to afforest. He sees undeniable proof of this in the extremely high wood increment of planted spruce, which exceeds the best Site I figures from Schwappach's German yield tables for this tree, in spite of the fact that the climate is barely cold enough to fall within Dengler's theoretical warm limit for practical success with Norway spruce as a forest tree.* Both Smitt and many Danish foresters believe heath plantations should be mixed instead of pure in composition. Some areas in Denmark now bear a second generation forest of pure beech which shows fair promise. This rapid improvement in the forest site is not usually possible. Quoting P. Graebner on the North German heathlands, Smitt advises that these poor sites should support a first generation forest primarily founded upon or consisting of pine,—especially the mountain pine forms,—introducing wherever possible an understory of tolerant broadleaf growth, when the conifers reach pole size. The second generation forest is considered as best when the following mixtures are attained:

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* Dr. Dengler, of the Eberswald Forest Akademie, believes Norway spruce cannot be grown on a profitable basis where the climate shows an average temperature above freezing (32 degrees F.) for the month of February.

(1) Spruce or European silver fir with hardwoods.
(2) Hardwoods alone.
(3) Larch with some tolerant species.

Such mixtures are not all adapted to soils of the same quality and must be chosen on merits of the site to be treated. Larch would only thrive on a soil of better quality.

Sitka spruce and several species of fir from the western U. S. are growing well upon soils won from the heather near Viborg and at other points in Denmark. They prove that these redeemed wastes are capable of supporting a variety of very valuable forest trees and yielding handsome returns of wood if managed with even ordinary care.

CHAPTER XII

FOREST REGULATION AND WORKING PLANS

These phases of the art of forestry are well developed in Sweden, altho the prescriptions of the working plan document are rarely followed with the blind obedience that is often obligatory in Central Europe. In both church and civil service under the government, it is not infrequent that part of the salary of an officer or employee consists of the income from some particular tract of forest. Under such conditions, it would seem very important to have cutting restricted to the actual increment of the forest, otherwise a hardship would likely be visited upon later holders of the office if the forest growing stock were reduced below the optimum by heavy cutting.

In the case of all public owned forests, the central Forest Service of the government makes stock surveys and drafts working plans that are binding within rather close limits. These plans are drawn at cost as a rule, or free of charge in some instances. They take due cognizance of local economic conditions and the wishes or opinions of the managers and beneficiaries of the areas in question, yet always justice and common weal rights are guiding considerations.

HISTORICAL BACKGROUNDS

Since the days of Linneus, Swedish land owners have held in general correct concepts of the forest and its need of conservation, *i. e.*, to say figuratively, they realized it was easy to "kill this goose that laid golden eggs." With such knowledge it was natural they should accept German forestry as a model along management as well as silvicultural lines. It was therefore common as early as 1870 to find larger private properties in South and Central Sweden covered by a careful forest working plan, drawn in minute detail and dealing with every stand, prescribing the cut to the exact cubic foot for 20, 40 and even 100 years in the future [52–102]. Provisions for planting with lists of number and species of trees to be set each year, and covering areas supporting stands to be cut twenty years hence, show the impress of German forestry thought of that date. Such plans naturally became obsolete in a few years, since unforeseen developments usually put them entirely out of step with the progress of events.

Plans of the type above described are now rarely met except upon government owned forests. The rule on private forests under management is to have periodic inventories of the growing stock with careful studies of the actual rates of increment. From a knowledge of the wood volume and quality of the forest growth at hand, it is a simple problem to fix quite accurately the optimum volume of the cut.

The forests upon large estates, which are primarily referred to in the foregoing, are among the best stocked and most conservatively handled in all Sweden. From 20% to 95% of the owners of all such properties call on the foresters of the provincial Forest Protection Boards (Skogsvordstyrelserna) for technical aid and advice in stock-taking and yield regulation; while from 16% to 50% employ consulting foresters for this service. Varying with provinces, as above, from 0 to 54% of these large property owners employ no technical advisers, altho all try to manage their area on a sustained yield basis except where financial difficulties have forced the forests into the hands of jobbers who hope to profit by devastation and "robber management." Most properties really suffer in money and volume production from having been too conservatively cut. Schager shows this in Table LXXXVI, covering more than 160,000 acres of these forests in South and Central Sweden, where under present conditions of economics and utilization it is considered that seventy years is the most desirable rotation length, yet every forest showed a considerable volume of growing stock above this age [52–108].

TABLE LXXXVI.—GROWING STOCK IN HYPERMATURE AGE-CLASSES ON SWEDISH ESTATE FORESTS

Total Area of Forests in Each Class	Proportion of Wood Volume in Stands 70 Years of Age or Older
1,791 acres	10%
49,123 acres	20–30%
29,294 acres	30–40%
9,884 acres	40–50%
13,170 acres	50–60%
45,763 acres	60–70%
15,444 acres	70–80%
164,469 acres	Total Area Studied

GENERAL POLICY

The preceding discussion gives a general concept of forest regulation upon the forests under certain types of ownership. For the large forest owning corporations, whose business is based on forest products, working plans must be very flexible, altho very necessary nevertheless. These corporations usually look upon their forests as a means of guaranteeing that they shall never lack raw material. They therefore cut their own forests heavily when the market is strong and other forest owners offer relatively less wood or logs than the manufacturing plants desire. Forests in this class of ownership are increasing in area and tend strongly toward stabilization of stumpage prices on a lower plane than might otherwise be possible, since the great consumers of stumpage are in a good position to depress prices by jockeying with the market when they can rely entirely upon their own resources whenever they feel that raw material prices are excessive. In order to gain the fullest advantage from their forest holdings, these companies must have a free hand in readjusting the felling budget whenever needful. On the other hand, these large aggregations of capital have always employed the best trained minds in stock-taking and handling their woodlands. They have, as a rule, more exact knowledge of their forest growing stock and its condition than any other class of owners, excepting possibly the State.

On the crown forests, the State has always drawn and executed rather rigid plans for keeping the cut on a sustained yield basis. This is very essential when personnel changes and the vagaries of the human mind must be guarded against. It greatly simplifies problems of management and prevents much repetition and wasted effort. The gravest charges against such plans are their prevention of heavy realization when market prices are good, and the requirement that a real effort be made to sell a considerable volume of wood when prices are low or faltering. In this way strictly enforced felling budgets tend to accentuate price fluctuations, though theoretically they should exert a steadying influence.

From the owner's standpoint, Sweden furnishes a splendid illustration of the monetary and forestal advantages that may be gained thru rational regulation of the yield, as contrasted to apparently expedient selling when markets seemed favorable. Table XVI and associated discussion in Chapter I, give a good picture of the Orsa "Savings-forest" (*Besparingskog*) in Central Sweden. Just north of it is the Hamra Crown-forest (*kronopark*). Both areas were visited and studied by the author in February, 1925, and a comparison on the ground is very much to the advantage of the state owned forest, altho the communal lands are well managed and provided with an extensive system of good forest roads. Cutting has always followed a conservative calculation on Hamra forest, while on Orsa forest business principles were given full sway, with the idea uppermost that all hypermature timber should be disposed of as rapidly as the market would take it at a fair net stumpage return, and with the understanding that cutting should proceed in such wise as to guarantee reasonably good regrowth. No objection can be raised against this policy so far as silviculture and economics is concerned. A hypermature stand is unproductive and stagnating, or possibly deteriorating, so far as net wood volume goes, altho it may have price increment in excess of carrying charges. It is simply common sense to replace non-producing old forest stands with thrifty growing ones. The net income from this operation can be funded and a double income is secured by the transaction. This was the viewpoint of the local people and officials who shaped the destiny of the Orsa forest. It has always been and will ever continue a popular theory with the lumberman everywhere [64–1924–232].

In 1884, when the comparison between the two forests begins, they were very similar in condition. Each supported nearly virgin stands of pine and spruce. Each had very similar topographic, soil and climatic features. If any advantages existed in any respect they

TABLE LXXXVII.—GROWING STOCK AND INCOME COMPARISON FOR REGULATED AND UNREGULATED FORESTS

Forest	Productive Area (acres)		Growing Stock Inventories							
			Volume (cu. ft.)				Value ($)			
			Whole Forest		Per Acre		Whole Forest		Per Acre	
	1912	1922	1912	1922	1912	1922	1912	1922	1912	1922
Hamra	63,427	66,178	98,979,411	80,148,249	1,559	1,211	2,603,998	2,991,520	41.05	45.20
Orsa	131,708	131,708	101,538,409	*128,727,279	772	977	1,602,112	4,600,346	12.16	34.93

Forest	Net Returns, Funded at 4¼% Compound Interest —1884 to 1912 ($)		Profit (+) or Loss (−) of Management for each Forest compared to what they would have returned if managed as the other was	
	Gross	Per Acre	Gross	Per Acre
Hamra	3,054,306	48.15	+1,933,053	+30.48
Orsa	6,130,575	46.55	−4,014,041	−30.48

*There were errors in the 1912 inventory of Orsa Forest. As these were corrected in 1922 it gives an erroneous impression of large net growth, when as a matter of fact, cutting and decay probably exceeded increment.

favored the Orsa communal area. In fact, it has always had a measurable economic advantage due to being on the average nearer markets. Small pine wood from the Orsa forest in 1924 could be disposed of for sulphate pulp at an average net stumpage of $.0144 per cubic foot, while on the Hamra forest this wood could only be charcoaled to yield a net stumpage of $.0057 per cubic foot. Spruce for sulphite pulp nets $.078 per cubic foot on Orsa forest, while on Hamra the return is only $.070. With these facts in mind, Table LXXXVII is so much the more emphatic in setting forth the gains due to regulation of forest yields on a sustained basis.

Table LXXXVII, comparing the regulated Hamra crown forest with the unregulated Orsa communal forest, is inadequate to show the whole true picture; since expenses have been different on the two areas. Administration costs upon Hamra forest average $.22 per acre per year, against only $.10 for Orsa. With regard to taxes, however, Hamra pays $16,426 annually, while Orsa pays $41,927. The average value at 1924 prices for stumpage on Hamra forest was $.037 per cubic foot, against $.036 on Orsa, because of depletion of the larger diameter classes. The annual increment on Hamra forest averages 1.03%, against 1.08% for Orsa.

TABLE LXXXVIII.—REGULATED FOREST VS. UNREGULATED

	Hamra Crown Forest	Orsa Communal Forest
1912 Funded Incomes Compounded to 1922—Amount—	$4,631,988	$9,297,284
Amount of All Income with Interest from 1912 to 1922—	2,150,397	1,374,876
Realization Value on All Present Growing Stock (1922)—	1,591,909	2,309,964
Totals	$8,374,294	$12,982,124

Table LXXXVIII probably tells the whole story most eloquently as regards the financial effect of forest regulation (Interest rate equals 4¼%).

Since the area of Orsa Forest is just about twice that of Hamra, the better management of the latter is self-evident.

A NATIONAL FOREST INVENTORY

In most countries it is now well recognized that there is a real need for economic land surveys with a special reference to present and future forest possibilities. This principle is well understood in the three heavily wooded Scandinavian countries, Finland, Sweden and Norway, and these countries have been steadily pushing forward very extensive forest stock and increment studies since about 1910. These lands have a special need for such work, because they are all heavy exporters of lumber and forest products. For many years it has also been freely predicted that the forests of the last two countries were tending rapidly toward exhaustion, which would be nothing short of calamitous to their respective people and national welfare. The reason back of this last statement applies equally to Finland, where 57% of the 1913 exports consisted of forest products. The relative value rising to about 85% in 1925 [21]. These northerly located peoples must wrest their livelihood from a region with an inhospitable climate in general, which limits the variety of products and requires importation of many commodities. These can only be paid for with services or products in exchange, and it is here that the forests of pine, spruce and birch play an important or preponderant rôle, justifying the best possible conservative business management, to which an inventory is a *sine qua non.*

In America we have had considerable experience with forest surveys of wide variety. Most of these have been of crude reconnoissance type, and nearly all limited in area to an individual property, particular working unit, logging chance or locality. Some work, however, has been both extensive and complete [7]. These surveys have, in every case, treated increment, present and possible, quite meagerly and crudely, or not at all. It is especially from this angle that Swedish forest inventory methods may be helpful precedents. The care and precision with which each detail of the work is done is quite typical of Swedish science generally. Some foresters may criticize a stock-taking that is expensive, and would rather continue along provisional lines, but thoro-going work makes future repetition less arduous and probably unnecessary for many years; since reliable increment, stand and site-quality data permit calculations which, with a little checking, will long serve as the basis of forest economics and management policy.

The work in Sweden started in 1911, when one province was covered more or less experimentally. This permitted the elaboration of the system followed later and served as a basis for cost calculations for its execution in other sections of the country. Further prosecution of the project was delayed until 1923, when it was again taken up in earnest and carried on under a standard outline which makes it in many respects the world's greatest forest inventory,—particularly as to the exactness with which data is collected, checked and computed [59–1926–37].

The system used may seem at first very like our usual strip-survey method with a gridiron of parallel lines, which in this work is laid out to cover entire provinces (three to seven million acres) as a unit, and also fitting together with the plan in adjacent ones, so the whole country may be finally covered. The control points for the lines were established in advance by the national topographic survey. The distance between them varies with the regularity of forest conditions and distribution in the different provinces. On the island of Öland they were only one kilometer (.62137 mile) apart, while in the rest of the three southern provinces they were spaced at five kilometers

(3.1 miles), in the central provinces at ten kilometers (6.2 miles), and further north at twenty kilometers (nearly 12½ miles). As the strips are only ten meters (nearly thirty-three feet) wide, the inventory percent varies for the most part between two-tenths and five-hundredths (0.2% and 0.05%) of one percent of the gross area, which is much less than usually considered necessary for reliable results in America, but in view of the uniformity of the forests of Sweden is quite satisfactory there. Such wide spacing of the strips was only adopted after actual trial proved the results with closer lines were only very slightly different as to gross totals.

Strips vary in length up to 255 kilometers, or nearly 160 miles, as a maximum. It is quite a feat to hold a true course upon lines of this sort in a region of vast forested mountains, glacial lakes and impassable bogs. Yet it is done with no instrument but a small open-sight staff compass, as a rule. Right angle offsets are made at times to correct any cumulative errors that throw a party off their true course, but this is rather rare.

The parties consist of ten men, usually. The chief looks after all details and is responsible in every way. He must be a graduate of the College of Forestry at Stockholm. A tally-man, compass-man, two caliper men, two chainmen, sample tree taker and assistant, and a burden bearer, complete the personnel. The compass-man drags the 100-meter (328 feet) guide line which fixes the party course.

The most striking features of the work are: choice and study of sample trees, checking for accuracy and classification of site.

All strips are divided into unit lengths of two kilometers (1.24 mile) with a tally sheet for each. For the most westerly forty meters, or 2% of this length, all trees are calipered and reproduction counted. Trees to a minimum D. B. H. of two inches are counted for 300 M., or 15% of the line length; and to a minimum of four inches for 1,000 M, or half the line. For the rest of the line only trees above six inches are considered. All trees above six inches D. B. H. must be actually calipered. For the stock under eight inches D. B. H. every 100th tree, throughout the full length of line in each two-inch class, is marked as a sample tree. For stock between eight and twelve inches every fiftieth tree in each two-inch class is taken as a sample. Every twentieth tree is taken between twelve and fourteen inches, and every tenth tree above that D. B. H.

These sample trees are very rarely felled, but are thoroughly investigated with aid of the increment-borer and recorded carefully as to some twenty or thirty facts. Each tree record is kept on a separate card and the increment-borer core is sealed in a tube and filed in the office for future reference checking. These arbitrarily selected sample-trees are the basis of the wonderful increment data secured. They supply also an interesting check upon the care with which field work is carried on. For each sample tree must be recorded its distance from the guide-line that marks the middle of the strip. This distance is measured with a 2½-meter stick used to control the width in general over which trees are estimated and counted or calipered.

There are five meters on each side of the center line and a totaling of the sample trees ought to average an equal number for each meter distance from the center. Now, if the fifth meter shows less than the average, it is patent that the party has consistently inventorized a strip of less than ten meters width. Moreover, the approximate error can be determined and correction made therefor. In 1923 a total of 35,581 sample trees were measured up and studied.

All strips are marked on the ground so that the central inspector from the Stockholm office can arbitrarily select two kilometer sections of lines for check re-running. Comparison of the data secured in this way by different personnel helps to keep the accuracy on a high plane.

Since the tally-man is only concerned with scoring up the number of trees and determining which ones shall be studied as samples, the party leader takes and writes up the stand descriptions, using one sheet for each two kilometers (1¼ mile) of strip corresponding to the area covered by a tally sheet. The following classification is used: treeless area above timber-line, cleared cultivable, water, solid rock covered areas, miscellaneous waste-land, bog or marsh land, and productive soil. The last two land types are carefully further classified. The undrained areas are very extensive and are listed from two standpoints: as to the sort of plant growth they support and as to drainage possibility. In this last respect three divisions are made: (a) land whose drainage is obviously practicable, (b) land where successful drainage is problematical, (c) areas whose drainage is impractical [50].

Productive forest soils are subdivided and studied in detail. Unforested slopes and pasture lands are first distinguished. Land where drainage would be justified to increase production is listed separately. The other forested areas are then classed in three vegetation types: (a) where lichens (reindeer moss, etc.) are predominant, (b) where true mosses predominate, and (c) where herbaceous forms rule the forest floor. All forest stands are listed under three other general heads: (a) satisfactory forest conditions, (b) less satisfactory, and (c) unsatisfactory.

As to age, stands are first listed as *even* or *uneven*. The former are much the more prevalent in Sweden and are grouped together in forty-year classes up to 161 years and over, as the final one.

Density of stand is rated in decimals, as in America, but it is not rare to find stands listed as 1.1 or more. This shows over-dense stagnating conditions. Where density falls below .25 the area is classed as blank.

SWEDISH SITE CLASSES AND AVERAGE YIELDS PER ACRE

Site Quality	*Mean Annual Yield (cu. ft.)*	*Site Quality*	*Mean Annual Yield (cu. ft.)*
I	150	V	49
II	114	VI	36
III	86	VII	26
IV	64	VIII	17

Nine site-quality classes are considered and stands are thus intensively and arbitrarily assessed by use of height on age tables, with data from the numerous dominant sample-trees. Only pine and spruce are used as indicators. The yield possibilities for the several quality classes are given below in terms of mean annual increment with optimum rotations and average good management.

The study of sample-trees in the field is very thorough. A separate card is filled out for each, carrying enough data to relocate it on the ground, to identify the tally-sheet and stand descriptions that apply to the area where it grew, and to correlate it with its increment borer core, which is preserved in a sealed pasteboard tube and filed in the central office for purpose of checking. Other facts recorded cover the character of site and stand where each tree grew, its age and that of stand surrounding it; D. B. H. outside and inside bark, height, form-height point, annual increment of leading shoot, thickness of last ten annual rings, general thrift and damage by any and all causes that may be discovered. The correlation of these trees with so many of the factors of site, stand, age and biology, permit many very valuable analyses and computations to be based upon them.

Much of the data collected has already been worked up and compiled by the party leaders and an efficient office force. Electrically driven adding and computing machines of U. S. make assist in the task. Efficiency and care are characteristic of this phase of the project, too. An actuary has determined the limits of error for each step as well, as most probable values for results, and constantly oversees every detail that might become a source of unforeseen or desultory error. The plan followed has been that of developing specialists in each line. For example, the man who has worked up the data on bark probably knows more about that feature of North European forest trees than any one else in the world.

The net results to date in this inventory will probably be published soon. It is needless to say that such an intensive-extensive study yields some surprises when comparisons are made with the best previous estimates of statisticians. The work in 1923 covered four provinces with a total land area of 14,510,000 acres, and resulted in finding about 800,000 acres less forest present than the Forest Service experts had always reckoned. This is an area nearly equal to the total productive forests of Denmark [45 and 72–3/9/25]. But the inventory showed so much better stocking and increment on the reduced area that former growing stock estimates for these provinces were actually exceeded. This incident makes one wonder what discrepancies a similar stock-taking would show in many of our American forest statistics, based so often on irregularly collected information and extremely variable understanding of the term "cleared land."

The forest inventory field work described costs about $3.40 per mile of line run, but similar work would cost more in America, due to higher wages. The average length of strip run per day in this Swedish work has been 3.35 miles [25–1925–395 and 64–1927–723].

FINLAND

The Finnish forest inventory surpasses the Swedish in the speed with which it was pushed to completion [21], and the tremendous area covered. In the brief space of two years practically the entire country was worked over, showing a gross productive forest area of 62,426,000 acres, carrying a growing stock of 57,210,000,000 cubic feet, with a current annual increment of 1,568,000,000 cubic feet, which is about 150,000,000 cubic feet greater than the present annual cut. The stock-taking in Finland was based on sample plots of 500 and 1,000 square meters (about 600 and 1,200 square yards) located arbitrarily every two kilometers (1.24 mile) along the course of lines like those used in Sweden. Along these lines the forest stands and conditions were estimated by eye. The gridiron of lines covered the land from the Arctic Ocean to the Gulf of Finland without a break and at even intervals of twenty-six kilometers (16.156 miles), except on the Öland Islands and in the best developed province of Nyland, where a spacing of ten and thirteen kilometers respectively was used.

The inventory in Norway follows much the same general outline as in Sweden, but with certain variations that adapt it better to topography and the selection form of forest met in the land of the Vikings. An example to the latter point, is the classification of productive forest stands in respect to previous treatment and resultant present stock,—as (a) Under-cut, (b) Normal-cut, (c) Over-cut, and (d) Robber-cut; the last term being applied to areas that have been denuded or devastated, so that the soil has suffered and the growing stock has been depleted.

NORWAY

The Norwegian forest stock-taking began in 1919, following carefully laid plans, in part prepared after conference with the Swedish foresters who laid the groundwork for the project described heretofore [29]. Computation and publication of results in Norway, as well as the prosecution of the field-work, has been well sustained and prompt. Five provinces, with a total productive forest area of 6,962,531 acres, were covered by the end of 1924. This forest area is 660,000 acres greater than previous estimates for the provinces in question.

More than half the forests of the country have now been inventoried and the assembled data carefully analyzed and published. The tables and graphs setting forth pregnant facts are highly illumunating and are fully explained by accompanying descriptive matter. With such an array of accurate information at hand as these great forest surveys yield, forest policy and management in Scandinavia is sure to register sound and rapid progress for decades to come.

MENSURATION METHODS AND OCULAR ESTIMATES

In the main, Scandinavian mathematics of forestry have been based on work done earlier in Central Europe, but the cruder and more economical procedure demanded in the less valuable and more extensive northern forests have given rise to numerous short cuts and adaptations. The most outstanding development of a technical nature has been Jonson's " Form-height-point " method of volume computation. This is an ocular estimate in a way, but has been refined and standardized by instrumental assistance and the use of carefully computed tables.

The Christen hypsometer is used to determine the height of trees, and by an additional special scale shows the locations of the form-height-point in percent of total height of tree above D. B. H. (4½ feet above the ground). Results obtained by this method are remarkably accurate when an entire stand or considerable area of forest is inventoried, altho it has been shown that for individual trees quite serious errors may occur [Petrini,—61–1919–163 and 1921–165].

Prof. Tor Jonson's method of timber estimating has been the object of much criticism and controversy for a decade past [61–1926 and 1927–63 and 495], but it stands the test of practical use and is sufficiently accurate for many scientific studies. Some of the critics maintain that the method is only a happy guess, but most of them admit it seems to have a basis on the biologic laws that underlie the bole development of trees. This is expressed mathematically in the engineers' formula for a cubic paraboloid which Jonson maintains can be applied to the bole of a tree above the basal swelling, since from there up to the form-height-point (defined as the center of gravity or center of symmetry of the crown), the trunk has the proportions of a columnar beam of equal strength thruout. The formula for calculation of the cross section of the bole, therefore, is

$$\frac{d}{D} = \sqrt[3]{\frac{l}{L}}$$

D and *d* are any two diameters taken on the bole between the form-height-point and the basal buttress. *D* is taken, as a rule, for practical purposes, as D. B. H. *L* and *l* are the respective distances of *D* and *d* below the form-height-point [23].

Professor Jonson has also worked up a number of other empirical tables that are very helpful toward increasing the accuracy of ocular timber estimates. Then, also, form factor tables are extensively used. These various tables, together with such statistical methods as are illustrated in the discussion of the national forest inventory, give consistently satisfactory results and are recommended for more general study and use in the United States and Canada.

VOLUME AND YIELD TABLES

In addition to the rather unique volume tables of Jonson (*Massatabeller*) mentioned heretofore, there exist other accurate and adequate tables of more conventional form for important Swedish forest trees. Some of these have been developed empirically for given localities and are very practical,—even in the hands of untrained woodsmen. Among the best tables of this type is one by Prof. Jonson for the "Approximate Inventory of Standing Forest." This table carries figures for total volume of the trees in cubic meters and then timber percent figures for the various D. B. H. values by two-inch classes.

Volume form factors are used to a greater extent in Scandinavia than in America as a means of determining the cubic contents of standing forests. They are probably somewhat more accurate than tables [74–630]. Tables developed in Germany and Denmark are also considerably used for checking up Swedish timber estimates and growth studies [3–414].

One of the best yield tables evolved in Sweden has been given in full heretofore (Table XVII). An earlier series of yield tables are those by Alex Maass, published in Vol. VIII of the Swedish Forest Research Station, 1911, dealing especially with pine. In 1922 a report was issued by the "Kolonization Kommittee," a body charged with studies to induce settlement and development of north and interior Sweden as a counter against emigration to Canada and the U. S. This report contains forest yield tables that illustrate what can be expected along the line of forest production under average good management on the sites of North and North-central Sweden (See Table LXXXVIII). Prof. Schotte has also worked up an excellent yield table for larch in Sweden, which may probably serve as an approximate guide for consideration of these species thruout the cooler North Temperate world so far as yield possibilities go [54–644]. It is to be noted that all three of these tables possess a considerable propaganda feature. The last table is a plea by comparison for the introduction of larch into the pine and spruce forests of Sweden, while the two first listed ones advocate thinning and intensive management as a means to heighten production.

USE OF GRAPHS

In both forest management and silviculture, Swedish foresters have made constant and extensive use of graphic methods to set forth and explain their ideas, to show the status of projects or to illustrate various phases of development. The reports of the Forest Research Station are replete with curves and other means to aid in visualizing work done and results achieved. Prof. Schotte, as director of the Research Station, was a firm believer in this sort of thing. The various forest exhibits held in Sweden from time to time, showed the public by means of attractive charts, diagrams and maps, the exact status of forestry and the welfare of Sweden from that standpoint. The catalog of forestry at the Gothenburg Exposition, in 1923 [26] gives a fair idea of the extensive use made of graphs as a means to public education in the economics and organization of forestry. Therein are used effectively about forty different types of graphical presentation.

The "Excursion Leaders" [57] issued by the Forest Research Station are also examples of how charts and curves may be used to supplement tables in setting forth forestry facts.

TABLE LXXXVIII.—YIELD TABLE SUMMARIES

Species and Author	Grade of Thinning	Quality of Site	Yield by Different Age Classes												Final Yields		
			Prior to 40 Yrs.		41–60 Yrs.		61–80 Yrs.		81–100 Yrs.		101–120 Yrs.		121–140 Yrs.		Volume Total (cu. ft.)	% Taken Out as Thinnings	M. A. I. (cu. ft.)
			Av. Vol. (cu. ft.)	T. %	Av. Vol. (cu. ft.)	T. %	Av. Vol. (cu. ft.)	T. %	Av. Vol. (cu. ft.)	T. %	Av. Vol. (cu. ft.)	T. %	Av. Vol. (cu. ft.)	T. %			
Scotch Pine by Maass	Light to Medium	I	1686	50	3098	42	4519	25	5636	17	6554	12	7763	7	13,340	41.7	95
		II	894	32	1873	42	2970	26	3933	16	4409	12	4699	7	8,227	40.5	58
		III	536	16	987	42	1907	18	2600	11	2860	7	2860	2x	x4,578	30.3	35
Scotch Pine by Kolonization Kommittee	Medium	I	170	67	741	29	1428	17	2032	19	2404	25	2414	29	4,502	50.2	32
		II	96	29	496	26	1000	20	1431	16	1790	20	1907	27	3,279	44.5	23
		III			312	32	714	22	1033	18	1279	19	1430	23	2,388	42.5	17
Larch by Prof. Schotte	None or Disregarded	I	2846		4819		6406								7,021	†	88
		II	2293		3990		5264								5,720		72
		III	1802		3275		4347								4,719		59
		IV	1378		2703		3561								3,875		48
		V	1011		2259		2932								3,189		40

Av. Vol. means the average cubic content of the stand during the period covered by the age class. On this the thinning percent (T. %) has been computed. For the period prior to 40 years, it is actually only 20 to 40 years that is considered by Schotte and the Kolonization Kommittee, while Maass bases his figures on 25 to 40 years for Sites I and II and 30 to 40 for Site III.

x Rotation only runs to 130 years.

† Rotation ends at 80 years for larch.

The data in Table LXXXVIII illustrates the wide differences between values in normal yield tables, such as given by Maass and Schotte and the empirical table for North Sweden. The site quality scales are also different for all three tables.

It is probable that in America we might get distinctly better results in certain public relations work if we presented pregnant forestry facts graphically wherever possible.

In working plans, also, charts are more helpful than tabulations in many instances. Our forestry personnel changes and shifts much more frequently than is the case in Europe, and it is only too frequent that valuable data accumulated during years of painstaking and expensive labor is thrown away or buried in musty files, when forest managers change, which would likely be valued highly and referred to constantly if it were recorded on a proper and attractive map or graphed on a wall chart.

SUBDIVISIONS FOR MANAGEMENT

Central Europe has supplied the model for all this work in Scandinavia, but departures in the direction of larger working and management units are the rule. Large compartments are set off on maps for record and orientation, but subdivided in the field into from several to many working units on the basis of topography and growing conditions. Rather seldom, except on " School Forests " and a few other intensively handled areas, does one see compartment lines hewn out in the woods according to a rectangular pattern, with uniform and carefully set stone corners, as is customary in Central Europe. On the management maps, it is usually some topographic feature, road or power line that serves to delimit compartments. The sub-compartments are extremely variable with natural and economic conditions, tending to be smaller as time goes on and wherever management is more intensive. The average size is smaller than one would expect, due in the main to the broken topography, varied past history of the forest and frequent boundary eccentricities. The units of working are probably never permanently marked on the ground, but are often very evident to the eye.

ROTATIONS AND CUTTING CYCLES

The working plans under which Swedish forestry proceeds are rather flexible in the main on the score of rotations and cutting cycles. This is especially true upon private owned forests and the more inaccessible northern crown forests and state lands where growth and deterioration are slow. There is a tendency for these features to be more carefully determined and definitely fixt as years pass. On the crown forests there has been a steady march toward full inventories for the growing stock on every forest (Revir). These inventories embody a careful investigation of increment and enable the central office (Domänstyrelsen) to fix the most desirable rotations. All working plan figures for age, in actual practice, really mean the corresponding average D. B. H. But when the forester and his staff mark and list trees for sale at the annual auctions, or at other times, they are always free to consider each tree on its merits and thus very efficiently apply the rule of commonsense, in contrast to the hidebound restrictions and prescriptions long prevalent in Central Europe.

METHODS OF FOREST REGULATION

With full cognizance of German forest yield regulations and after numerous attempted applications, it may be said today that commonsense has also prevailed over dogma and formulæ in this field so far as actual practice goes. Both area and volume methods of regulation are met and serve as a rough guide, but in general it is the custom to base the determination of the cut on a careful stock survey. This sets forth the area and volume of growing stock for each age and class. With this schedule before him and taking due notice of accretion and deterioration, the working plan specialist makes an allotment of the cut to be made during the next decade or twenty-year period, in order that the forest may progress toward the ideal of normality and sustained maximum yield. Allotments of the cut are most commonly by volume, or if by area a volume check is made.

THE WORKING PLAN DOCUMENT

In Scandinavia and Finland this phase of forestry is not generally very formidable. It usually embodies a few general and simple but clear guiding statements with the best possible maps and tabulated data. The forester in charge is commonly given a free hand in locating his cut and proceeds about this somewhat after the volume " framework " method.

In Swedish state forestry, the central office drafts the working plans, with the assistance and advice of the forester in administrative charge [64–1928–217]. Definite plans have not yet been laid down for more than 25% of the crown forests, but general provisional determinations of the cut have long been in force.

The great problem of management in North and even Central Sweden is the cutting of the hypermature stock in the forest and its prompt replacement with thrifty growing younger age classes. The district foresters and central officials sometimes complain because the administrative forester in charge of the various forests cut, or assign for sale and cutting, so many small trees while large and hypermature specimens without increment are permitted to remain in the forest. Table LXXXIX shows the dimensions of the trees sold at auction in the southern forest district of North Sweden during the five years 1922–26. In this district the rotation is set at 120 years, yet of the total state forest area, 272,400 acres, 107,639 acres are occupied by stock above 120 years old and 86,878 acres by stock above 140 years.

By its nature, this table showing number of trees may be misleading, since many smaller trees may be unthrifty, yet it is probably a source of danger where working plan restrictions are lax, that forest managers may locate their cut on the more accessible areas where a greater net income will accrue, while the inaccessible and stagnating stands of hypermature and defective timber in the hinterland remain to cumber the ground, because cutting it would yield but a low net return, possibly thereby discrediting the manager when judgments are based on balance sheets and budgets rather than field examinations.

TABLE LXXXIX.—TREES SOLD AT STATE FOREST AUCTIONS IN CENTRAL SWEDISH FOREST DISTRICT DURING FIVE YEARS, SHOWING D. B. H. REPRESENTATION

D. B. H. (inches)	Number of Trees	Percent of All Trees Sold	
5	233,476	7.4	53.9 = Young
6	471,012	14.8	
7	525,844	16.6	
8	479,983	15.1	
9	404,008	12.7	39.7 = Middle-aged
10	324,621	10.2	
11	241,178	7.6	
12	172,411	5.5	
13	118,391	3.7	
14	76,563	2.4	6.4 = Mature and Hypermature
15	48,201	1.5	
16	29,429	.9	
17	20,019	.6	
18 and over	30,093	.1	
	3,175,229	100%	

In North Sweden there are two added temptations that assail the administrative forester along this line. Small spruce trees are quite valuable for the pulp they make and are thus readily marketable. Reproduction of the middle-aged forest stands is far easier,—more certain and less expensive,—than is the case with the hypermature stands where seeding is rare and raw humus combined with scrubby dwarf undergrowth and heath shrubs make natural regeneration slow and uncertain.

CHAPTER XIII

FOREST ADMINISTRATION

This subject has been treated incidentally in all the foregoing chapters, but certain details and phases remain and merit special discussion. It is especially notable in Sweden, that in spite of the wide variety of forest ownership, administration is still quite uniform and tends to be standardized in most respects.

LEGISLATION AND POLICY

Unlike Central Europe, where forestry may be looked upon as a natural development through the course of centuries, in Scandinavia this very essential human activity has been constantly fostered by law. It has been assisted at every step by the patriotic foresight and thought of economists and statesmen, which was crystallized into laws that restrain or direct the activities of private land owners on the one hand, while on the other they provide for practice of the best economically possible forestry on public holdings. In this feature of forest economics and history, as well as the necessity for the most rapid introduction of forestry methods, these North European lands offer a far closer parallel and advanced example for America than do such countries as Germany, France or Switzerland.

It is comforting to the pioneers backing forestry in America, when they note how often laws have failed in whole or part to attain their objective, yet always they have had a salutary educational effect. Wahlgren writes most interestingly on the forest history of Sweden [62–1 to 248 and 63–1 to 36], and a volume would not suffice to set forth the various laws and makeshift regulations which served their purpose indifferently well during the first century of Swedish Forestry. Space will not permit even an outline of the development of forest administration, but in order that the New World may profit by the trials and errors of these most democratic lands of the Old, the trend and present status can be sketched in a few words.

Forestry in the early nineteenth century was in the main an idea of the upper strata of society, which they attempted to foist upon the people long in advance of its economic time. As etymology denotes and history abundantly records, Swedish forestry, like that of most European lands, was first based on love of the chase and a desire to perpetuate game and the manly skill necessary to take it [63–2]. Naturally, forestry was not popular with the common people, and resentment against restrictions imposed continued until the diffusion of knowledge and changed economic conditions gave everyone the vision to discern the need for forest conservation and improvement from a general welfare standpoint.

From the above facts, it may be surmised that forest administration was at first highly centralized. It can, in general, be stated that the success and proficiency of the art and profession has been in exact proportion to its decentralization. The tendency is still strongly in this direction, as indicated in the recent proposal to divorce the Church Forests more or less completely from the central Forest Service of the nation [28–200]. The " Forest Protection Boards," with their provincial foresters, working under the law of 1903 and later amendments, has been the greatest step in the direction of independence and progress. Schager [52–283] and others show also how the good independent forestry practiced on property of large corporations stimulates other owners and managers to better practices [25–11/1927–893]. In short, the secret of progress and efficiency is *Emulation.* With centralization and bureaucracy come stagnation and internal strife with useless bickering over non-essentials; while more or less complete independence promotes effort to excell, with that divine spirit of contention as to who may the better serve the common cause of mankind and the profession.

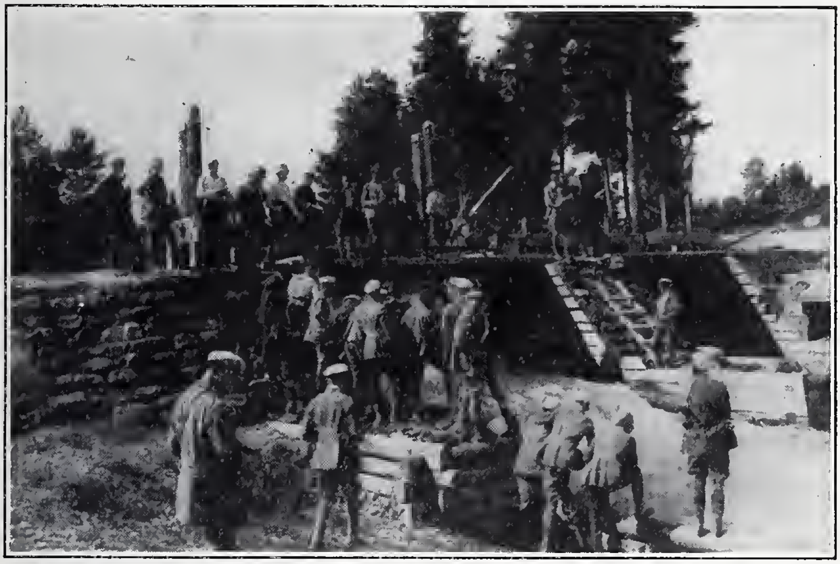

Fig. 11.—Students from College of Forestry Study River-driving Problems.
Splash-dam on small stream to facilitate log-driving.

LAWS ON HUNTING AND FISHING

Americans are usually surprised at the inadequacy or folly of European legal efforts for the conservation of wild life. It seems a paradox that game there was more important than the forests a century or more ago, yet today we have progressed further in America along the line of its protection and propagation than have the countries of the Old World. The game refuge or sanctuary idea is still not given much consideration in Europe. It has, however, been in vogue incidentally ever since the Dark Ages and is the only reason why three-fourths of the wild life species have escaped extinction. The estates and hunting parks or preserves of the nobility were always stringently protected and rarely hunted very hard. They have served a useful purpose and should be replaced by havens under government protection and supervision.

The Swedish people rival, or possibly surpass the English in their love of shooting and fishing. It is undoubtedly an hereditary trait of the race, which often served in the past to preserve the lives and health of the most vigorous fraction of the population during winter periods of starvation. Wild life was abundant in the Baltic lands originally, and even down to quite recent times. It is recited that in the early nineteenth century [63–2] fires had to be kept up all night around the yards of the royal hunting park on the outskirts of Stockholm, to prevent wolves and lynxes from killing the king's deer during cold mid-winter periods.

Game laws in Sweden are generally only provincial in application. This means there is much confusion in the laws and regulations. Exceptions to the provincial laws in 1928 were the stag, which could be killed everywhere during the month of November; the fallow deer during November, October and the latter half of September; the woodcock at any time after the middle of May; wild pigeons after the first of August; and a couple of minor water birds that can be hunted from September 1st to April 20th.

It will be noted that all these countrywide seasons are exceptionally long, as is usually true also of the provincial seasons if the elk alone is excepted. This king of Swedish big game is favored with a season of from but one to five days, which begins universally on the 10th of September in North Sweden and the 10th of October in the South.

Game law enforcement in the several provinces is largely in the hands of Game Protective Associations which are affiliated in a powerful nation-wide organization known as the " Swedish Hunter's Union " (Svenska Jägarforbundet). These interested societies in actuality propose the laws which the national legislature passes. Yet game of nearly all sorts is very scarce in Sweden, and no phase of the laws and customs heretofore mentioned can really be especially recommended.

The kill of elk in Sweden was 1,746 in 1926. Of these, 1,545 were bulls and 182 cows, with 18 killed of unknown sex. It was illegal to kill elk anywhere during the period of 1921–24. Calves cannot now be killed, and in some provinces killing cows is forbidden on private lands [59–1/15/27–41]. Considering the wide extent of Sweden, its thin population, topography and cover conditions, the kill of elk has never been large; as shown in Table XC. Reckless killing of cows and calves would have soon sent this species the way of the musk ox and a number of other animals that once roamed the forests of Scandinavia.

Elk often work considerable damage [59–7/15/28–387] to young growth in Swedish forests. In serious instances, forest officers are given special permission to kill them in given localities.

Bears are now very rare in Scandinavia. In Sweden they have been long more or less considered the special quarry of kings [59–1/1/27–17]. Once they were quite abundant and had a bounty upon them. Since 1912 bears have been absolutely protected on crown lands and are now undoubtedly on the increase. During the years 1923–25 bears killed 146 domestic animals in Sweden.

TABLE XC.—Kill of Elk in Sweden,—1911 to 1926
Report of Domain Commission (Central Forest Service)

Years	Bulls	Cows	Calves	Sex Unknown	Total
1911	1,310	1,089	202	52	2,653
1912	1,337	1,073	157	82	2,649
1913	1,366	1,163	239	86	2,854
1914	1,177	1,040	200	50	2,467
1915	1,267	1,138	247	127	2,779
1916	1,296	1,123	205	65	2,689
1917	1,121	1,016	122	130	2,389
1918	1,104	996	36	53	2,189
1919	791	680	7	31	1,509
1920	563	489	12	10	1,074
1925	1,117	707		64	1,888
1926	1,545	182		19	1,746

Stocking of areas with game species adapted thereto has long been the practice in Sweden. We can learn wisdom in America from Swedish game propagation experience [59–2/1/1928–64]. One of the best authorities in the country, if not in all Europe, is Prof. Gustaf Lundberg. He is very insistent that only acclimated breeding stock should be introduced in a region to strengthen the game population, otherwise the remnant of the native stock is weakened in its power to withstand climatic rigors and the species may be extinguished over a wide locality; being actually killed off by the misdirected kindness and energy of its well wishers and friends. The U. S. Biological Survey (John C. Phillips, April, 1928) has recently arrived at the same conclusion concerning the bob-white or quail of the northeastern states, which has lost a large territory at the northern part of its range by contamination of the original hardy blood strain through introduction of breeding stock from the South, and even Mexico. Introduced game animals and birds from a warmer region may survive one or even several winters if these are favorable as to weather and food supply, especially where feeding is resorted to during times of heavy snow. This permits considerable interbreeding with the native individuals of the species, and the whole strain may become quickly weakened so it is completely wiped out by an exceptionally severe and persistent winter.

THE PERSONNEL OF FOREST ADMINISTRATION

From Table VIII the reader has seen how the Central Forest Service is officered. There is no lack of organization in private forestry or other public fields. Education in the profession has probably been overdone during the second decade of the century, and it is quite difficult for many foresters to find employment when they leave the College of Forestry as full-fledged graduates. The large corporate forest owners have in general a very adequate staff of trained men. These usually have attained their positions by promotion up from the ranks, except in the highest grades, where it is usually tacitly understood that a graduate from the College of Forestry, or its predecessor, the Institute of Forestry, is required for the positions. For lower grades men from local short course forest schools are now preferred.

Choice of personnel is not always easy, due primarily to the large number of applicants. The choice of forest officers is in general quite similar, whether the employer is the State, a provincial forest protection board or some private concern. The position may become vacant by death, retirement or resignation of its previous holder, or it may be a newly created position. In any case, the first step seems to be to print an advertisement declaring the position vacant and requesting applications for appointment prior to a given day and hour. A committee of some three or more qualified men, possibly the directors of the corporation if the job is in private corporate employ, or certain officials in case of the government, will go over the applications and carefully study the qualifications of the various men who seek the position. They finally list two or three whom they deem best capable of filling the position to the satisfaction of the employers or public. They may especially recommend the appointment of one of the applicants if they find special grounds for this. The director or responsible person then makes his appointment from the approved list. The appointment may be permanent or for a definite period of years, or it may be merely temporary or probational.

When instructors are chosen for the College of Forestry, it is the frequent custom to have the applicants appear before the students and committee there, to deliver on fixed dates, one or two " proof " lectures on some phase of the subject they hope to teach. This enables the committee to choose very intelligently the sort of man who is efficient in the lecture room and able to put his ideas across to his hearers [59–1/1/28–2]. It is commended to American attention as being far superior to our prevalent custom of choice on the basis of collegiate degrees, which only too often represent the doing in a grudging and slovenly way of a certain minimum of " potboiling hack-work," a little reading, copying of an impressive looking bibliography, and some time *in residence* at a higher institution of learning.

Legal enactments in Sweden commonly cite definite minimum educational attainments as necessary to holding certain positions in the State service. Private employers imitate the government in these matters, so that now in order to rise from the ranks it is usually necessary to have good basic training, or else to take a course in one of the several local secondary forestry schools, if a man wishes to attain to a ranger-grade position (*kronojägare* or *skogsverwaltare*). It is also far more difficult to rise by promotion on the basis of ability in the Old World than in America. This is an unavoidable corollary to the stratification of society that develops in older lands.

Swedish forest officers do not hold military rank, as is the case with corresponding positions in government forestry of some other European countries. Practically everyone has, however, served his time as a conscript in the army and some have attained and hold an army grade in addition to their professional standing. Whether in public or private employ, every forester and ranger may look forward to retirement on pension in case of disability or at the age of sixty-five years.

TABLE XCI.—LABOR WAGES PER DAY

	Summer	Winter
Pay for Laborer without meals	$1.72	$1.17
Pay for Laborer with meals supplied	1.53	1.00
Pay for Horse and Driver	2.65	2.48

The pay of Swedish foresters is by no means princely so far as money is concerned. Only exceptional men receive in excess of $2,500 per year. In this class are the district foresters and experienced instructors at the College of Forestry. Most administrative officers with highest training in forestry get about $2,000 per year, and many even less. From this salary they must provide their own personal quarters. Employees of ranger grade usually receive $600 to $1,000 per year, but often have quarters of very comfortable character provided. By way of comparison with the wages paid forest laborers in Scandinavia, Table XCI gives average rates prevailing in 1926 and '27 [59–8/15/27–373]. The lower pay in winter is due primarily to the shorter working hours, usually eight or less, while in summer ten and twelve hour days are not infrequent in many forest and farming localities.

The forester has other compensations not possible of monetary evaluation. One of these is the social esteem which appertains to the position, and this is an important matter in Sweden and European lands generally. The forester, and even rangers, are pillars of society in their respective communities. Their work is also pleasant and not usually especially onerous. Hours are short and a man is largely on his own recognizance so long as he measures up to accepted standards of efficiency.

THE EDUCATION OF A SWEDISH FORESTER

("Studiehandbok för Skogshögskolan," 1919.)

Since practically all forest administration in the country is in the hands of graduates from the College of Forestry at Stockholm (*Skogshögskolan,* and its predecessor *Skogsinstitutet*), the course of study and requirements of this splendid school are briefly outlined below. The school gives two courses which seem very similar, except that the lower grade course is shorter and more concentrated, lacks the preparatory year and is intensely practical in objective.

Both courses require that students be sound in body, possessed of good eyesight and graduates in good standing from the science course of the public schools. In the higher course they must not exceed twenty-four years old and in the lower twenty-six years. In the higher course, a preparatory year of study and practical forestry work must precede matriculation. The first half of this preparatory period is strictly probational, while the second is so to a certain degree. Table XCII gives in summary the curriculum for both courses at the college.

The total time required for a forestry education is seen to be 2,533 and 2,392 hours of actual instruction in the respective courses, not reckoning in the two preparatory semesters required in the higher course and certain rather variable periods spent on field-trips and not definitely stated in the College catalog. It may also appear odd to Americans when they note the fact that both courses end in midwinter at the holiday season instead of spring or June, as is customary with us. This has certain special reasons, and might be wisely adapted by our own forest schools.

The special reason for ending these courses when they do lies in the examination custom prevalent in most Swedish colleges and universities. Students do not necessarily take these at the end of a course,—in fact, may never take any at all, and yet go to classes so long as they meet such social and financial obligations as are laid upon them. Of course, in order to graduate, examinations must be passed finally, but under the *tentamen* system, instructors may call students up in groups, or even individually, at such times as are convenient, and give them a very thorough test to determine their fitness for passing the course or subjects prescribed. These tests are often oral instead of written. Students at the College of Forestry commonly attempt the examinations during the long period from about January 20th to May.

Ending courses in midwinter also gives students time to make up all back work and do special reading or research in some assigned subject, rather of the nature of thesis requirements in American schools. It gives the graduate ample time to look around and obtain

TABLE XCII.—COURSES OF STUDY, COLLEGE OF FORESTRY, STOCKHOLM, 1925. (SKOGSHÖGSKOLAN)

L = Lecture Hours.
F = Practical work and field trip hours.

D = Drafting, computations and laboratory work.
Higher Course (*Jägmästarekursen*).

Terms or Semesters

Subjects	1 Fall		2 Spring		3 Sum.	4 Fall		5 Spring		6 Sum.	7 Fall		Totals		
	L	D	L	D	F	L	D	L	D	F	L	D	L	D	F
General Botany	36	27											36	27	
Forest Botany			44	33	80								44	33	80
Soils			44		40								44		40
Geology and Minerology	27	9			40								27	9	40
General and Vertebrate Zoology	18		22										40		
Forest Entomology			33		60	9	14						42	14	60
Organic Chemistry	18												18		
Technical Chemistry						9							9		
Meteorology	18												18		
Forest and General Law	18		22			18		33					91		
Silviculture			22		140	18		36		180	18		94		320
Forest Mensuration and Regulation	18		33		250	18	18	11	22	180	18	27	98	67	430
Utilization and Engineering	9		11		250	36		44	33	140	9	27	109	60	390
Forest Politics and Statistics						9		33			18		60		
Business Methods											27	27	27	27	
Bookkeeping											9	18	9	18	
Economics of Farm and Forest						18		22		70			40		70
Game and Fish						9		33					42		
	162	36	231	33	860	144	32	212	55	570	99	99	848	255	1430

TABLE XCII.—*(Continued)*
Lower Course (*Forstmästarekursen*)

Subjects	1 Sum.	2 Fall		3 Spring		4 Sum.	5 Fall		Totals		
	F	L	D	L	D	F	L	D	L	D	F
Botany		18		33	11	50			51	11	50
Soils, Geology and Meteorology	20	18	9	22		20			40	9	40
Forest Geology		18		22	11	40			40	11	40
Mathematics		36	27						36	27	
Surveying	250	18							18		250
Silviculture	120	9		33		350	27		69		470
Forest Mensuration and Regulation	200			33	22	150	18	27	51	49	350
Forest Utilization and Engineering	40	27		66	22	350	27	18	120	40	390
Rural Economics	20	18		22		30			40		50
Forest and Business Law		18		33					51		
Bookkeeping							9	18	9	18	
Fish and Game Culture							18		18		
Mapping and Drafting			45							45	
	650	180	81	264	66	990	99	63	543	210	1640

employment, as well as permits him to report promptly in spring, which is always the busiest and most important working season for the practicing forester and woodland owner.

FOREST PROTECTION

In Sweden and Scandinavia this has little to do with fire. There is scarcely a fire-tower in all the four Baltic lands. Finland occasionally has stubborn fires in the north, and this was also once true of Sweden [74–381 and 390], both there and on sand dune or heath areas at the south. Human encroachments, such as unlawful grazing and theft, are most to be guarded against, but the protective organization has largely solved these problems and is now maintained primarily to lead the labor forces in silvicultural and improvement activities, while also guaranteeing safety from the resurgence of the old lawlessness that once nearly wrecked the best forests in public possession.

Insect depredations are always to be feared, but have rarely done serious injury in Scandinavia. An organization helps very effectively to forestall trouble, however, as has been illustrated in case of incipient outbreaks of the nun moth in South Sweden [74–506], as well as the spruce sawfly (*Lymantria monacha* and *Lyda piceæ*) [74–507 and 61–1919–102].

FIRE INSURANCE

The phase of forestry that is most discouraging in most parts of America is the fire problem and the threat of heavy financial loss, that hangs like the sword of Damocles over every forest investment. Regardless of how well organized forestry may be, fires can still occur under exceptional conditions, and its menace paralyzes the initiative of many land owners. From the standpoint of forest administration, it is therefore quite desirable to examine the solution worked out for this problem in Sweden and neighboring lands.

Every one of these four progressive lands has commercial forest fire insurance. Finland shows most development in this field and has certainly made the most careful and scientific studies of the subject as a whole. Denmark is most backward, with only one concern, the Heath Society (*Hedeselskabet*) offering to accept risks, with a limitation to plantations and liability extending merely to their replacement in event of destruction.

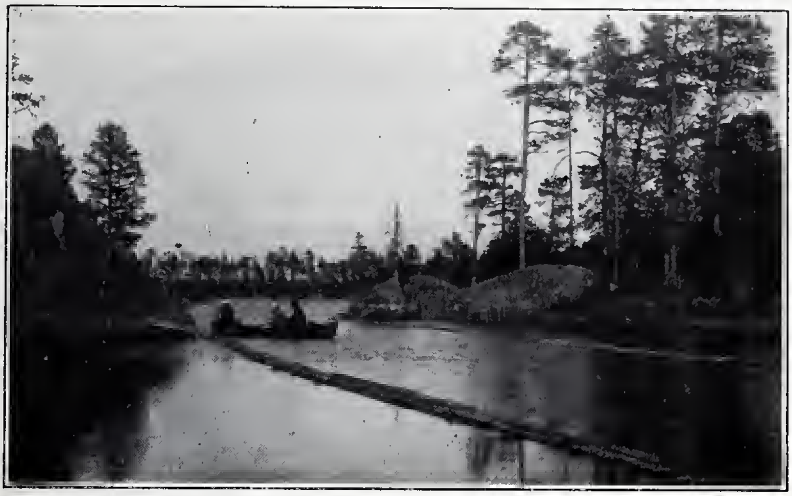

FIG. 12.—CHANNEL ACROSS SWEDISH LAKE TO PERMIT LOG-DRIVING.

The lakes typical of Sweden are both assets and liabilities to water transportation of logs.

Finland had a mutual company writing forest fire insurance as early as 1914, and other concerns have entered the field since. In this country the fire loss risk is higher than in Sweden or Norway, hence there are numerous districts and grades to classify hazards and determine an equitable premium, which must naturally average higher than in neighboring lands.

Norway was the pioneer among these countries in forest fire insurance and probably incorporated the first strictly forestry insurance writing concern in the world in 1912. Progress there has been very steady and shows many practical features worthy of imitation. The chief of these is "Insurance for all Eternity" (*Allfremtidsforsikring*). This form of insurance consists in paying one considerable premium, once and for all, which permanently guarantees the area concerned against fire loss up to a specified sum. In case annual insurance is desired, the premiums are rather high for the first year or so and thereafter scale down rapidly and become paid-up permanent policies after twenty-five years. The amount of insurance written on a given property is fixed by the owner himself, but in case of loss, the claim paid is either agreed upon by the owner and company or each appoints a representative and these choose an umpire, then this arbitration committee adjusts the loss as they deem equitable. Nearly all forest insurance in Norway is still written by the original mutual company, which carried risks in 1928 to the sum of nearly $100,000,000 and had accumulated funds to the extent of $525,000.

In Sweden the forest fire insurance business is divided among some four or five companies, whose chief interests have long been in other fields and only entered forestry as a side line.

In all these countries it has long been possible to insure logs, lumber and sawmills. Such risks are accepted by general casualty companies at rates that would seem low by contrast to those prevalent in America for like service. The most progressive Swedish company will insure forests and their products at every stage from young plantations to delivery of lumber or other products in distant foreign lands.

Insurance on forests has a very beneficial effect upon the general business of a country, as it liquidates " frozen assets " in time of financial stringency. When a forest is insured against fire loss it becomes one of the best investments in the world from the standpoint of safety, and will be readily accepted as security for loans even by the most cautious business men.

TIMBER SALES

This phase of forest administration is especially weak in connection with American public lands. There seems to be an abiding fear that " graft " or corruption must be guarded against regardless of every other consideration. Red tape, delay, lack of flexibility and fear of public criticism are factors that, singly or combined, practically paralyze public forestry as a remunerative business. It is the sensible sales methods in vogue in Scandinavia that primarily account for success there under adverse conditions that are rarely surpassed in the New World, and such as have no parallel in Central Europe.

Losses due to the dishonesty or connivance of employees is probably a matter of little moment in the long run anyhow, and can be absolutely prevented in only one way,—the appointment and retention in places of trust of men whose integrity is above question. Such men can be safely given a free hand to manage any business if they are well informed along needful current economic lines. The foregoing principles are the basis of Scandinavian timber sales policy. Experts study conditions in the forest and with reference to both local and general markets. Transportation and accessibility are given due weight. From the integration of all these and other special factors, a decision as to methods of sale and utilization is made and then efficiently executed. In this way government forestry is made to pay a profit.

The general sales policy in Sweden has been outlined heretofore and is only touched on here to show details of the most common method of marketing. The first step is to make up a careful and exact description of the trees to be sold, including their exact location. This also usually means that each tree is marked and measured up, altho sometimes where an area is to be clearcut or cut over to a fixed diameter limit, the area is merely measured up, mapped and described with a detailed description of cutting methods or silvicultural restrictions to be adhered to. When stumpage is bought this way every step in utilization is carefully inspected by the ranger and forester in charge of the area. Wherever reproduction conditions are difficult, or special reasons exist for care in lumbering, it is becoming more and more the practice to sell the logs delivered on the bank of some drivable stream. In this way the cutting and skidding is done by the forest personnel and every possible provision can be made to guarantee the safety of young growth.

TABLE XCIII.—AUCTIONS OF CROWN FOREST TIMBER, 1928

Location of Auction	Trees Offered for Sale	Trees Sold	% of Total Trees offered	Total Selling Price ($)
Umea	2,884,012	2,281,248	79	1,010,097
Lulea	1,438,646	1,059,349	74	438,715
	2,495,640	2,078,700	83	838,846
	447,503	231,028	52	83,689
Solleftea	1,188,243	895,593	75	393,619
	96,139	39,740	41	11,523
Östersund	532,411	479,803	90	289,935
Sundsvall	201,351	174,177	87	130,072
Totals	9,283,945	7,239,638	78%	3,196,496

Some sales are made by advertising for sealed bids, but in each forest district, as well as on each forest, as a rule, there are annual public auction sales of stumpage or logs in quantity to suit the convenience of the bidders. In general, the Forest Service has a set minimum price on each block of stumpage offered. When this is not exceeded by the bidders there is no sale for the time being. All sales are advertised a month or more in advance as to place, day and hour, with the general location of wood to be sold. In case of these auctions, only verbal bids made in person, or by accredited representatives of responsible parties, are usually acceptable [59–1/10/28–514-V]. These auctions occur in autumn, about October first, as a rule, and are held in the town hall of some considerable city or in a public assembly place. Prospective bidders can always get in advance, from the district foresters, a complete catalog of the timber to be offered for sale. This is listed in convenient quantities known as "posts" (*Poster*), each of which is given a number for purposes of bidding and sale. Table XCIII gives the result of the 1928 auctions in North Sweden and illustrates briefly how simply the Forest Service conducts a big business [59–11/1/28–566].

For the previous year (1927), these forest districts offered for sale 8,845,279 trees, of which 6,543,899 were sold (74%) for the sum of $3,319,724.

CHAPTER XIV

FOREST UTILIZATION

[Reference: "Handbok i Skogsteknologi," Stockholm, 1922.]

Relatively few features of Swedish forestry are abreast of American practice in this general branch of forestry as a business, but some certain phases are in advance of New World methods and will be emphasized hereinafter. It is also a matter of remark that so many features of woods work differ radically when Sweden and America are compared, especially when it is remembered that since about 1890 or earlier, there has been a constant quite considerable flux and reflux of Swedish forest laborers to and from America. The writer was surprised, in 1925 to find six men in a single small lumber camp in Central Sweden, who had worked from one to five years in the United States or Canada, and then returned to their native land without the riches that each dreamed he could quickly acquire in transatlantic eldorados.

The persistence of crude tools and inefficient methods all over the Old World is an eloquent but sad commentary on the conservativeness of the human race. Double-bitted axes were not observed in use at all by the writer in the forests of twelve European countries in 1924–25. Not a single axe-mattock was seen in the woods and more remote localities of these countries. These two most efficient examples of the all-important silvicultural tools were not even found in the museum collections of tools at the leading German (Eberswalde) and Scandinavian forestry schools. On the other hand, in a number of respects, river driving and pulp-mill methods and equipment are better than to be found in America. The reason for the slower adoption of improvements and new ideas than one would expect to find where there has been so much exchange of labor, lies primarily in the social status of the transient laborer. The suggestions of a " Greenhorn " Swede would usually be received with scant respect on American lumber jobs; while when we recall the lowly status of labor at the best in Sweden, it can be imagined how much influence a failure in the shape of the homesick returned emigrant would be able to exert toward changing the customs or tools that had stood the test of centuries. In fact, it has always been the experience of successful naturalized American citizens who return to visit their native lands, that suggestions "don't get very far." Hearers usually listen respectfully and then say: "Well, that may be all right in America, but it is different here. This is Sweden, an old and cultured country."

At present there are many hopeful signs that indicate a far freer interchange of ideas between the Old and New World, especially is this true of Scandinavia. Numerous forestry graduates from the college at Stockholm, as well as from Denmark and Norway, have sought and found forestry or woods work in Canada and the U. S. A. Each year the American-Scandinavian Foundation grants fellowships in forestry which lead to the exchange of students. These educated and trained men will be far more potent than thousands of untutored laborers, when it comes to choosing the best ideas and crystallizing them into something concrete and tangible toward the progress of forestry in all the lands concerned.

LOGGING EQUIPMENT AND WOODS WORK

Power logging, such as has so rapidly stripped bare the forest lands of America, is unknown in Sweden. Railroad logging is extremely rare in Scandinavia and usually limited to transferring logs over divides between water courses. The visitor to Swedish forests quickly realizes why steam skidding and " high-lead " methods have never been thought of there. The logs cut and handled are almost unbelievably small on the average, and even the largest logs would be rated as very small sticks in our Southern Pine Region or on the West Coast. In 1924 Sweden was visited by two or three Canadian foresters who were primarily interested in ideas that would make for greater efficiency in getting logs from the stump to the mill. These men were entertained and guided about by the Swedish Forest Service for some days, and while they manifested interest in what they were shown, yet they constantly asked to see how big logs were handled. Their Swedish hosts therefore took them to the Hamra Crown Forest in North-central Sweden, where the best of the virgin forest remnants of the country are located. When the Canadians arrived there and saw laborers on the skidways and landings lifting the logs around with " ice-tongs " or by hand, it was too much for them. They made a few contemptuous remarks to the effect that " toothpicks and saw-logs were very different things," and inquired when the next steamer would sail for Canada. Yet it must be recalled that from these relatively small logs, especially as to diameter, the Swedish sawmill industry cuts out fair quality material that competes successfully in the markets of the world against the clear widths from the giant trees of British Columbia, Oregon, and Louisiana.

The small size and uniformity of the logs is a great advantage in utilization, both in woods and mill, as well as from the standpoint of transportation. The peavy and canthooks, so necessary in America, are rarely or never met in Sweden. A light barkspud with a curved hook fastened near the lower end, so it can be loosened and used as a canthook, has recently come into limited favor. One-man saws are the universal rule. Most of these are very light and cut a narrow kerf. The " bow-saw " is most popular, and is quite similar to the old " buck-saw,"—associated with the family woodpile in America. The Swedish bow-saw, however, usually has the bow portion made of tubular steel. At the end, where the saw-blade and tip of the bow are joined, there is usually a hole to which a detachable spring is attached when the saw is being used. This spring is a simple wire coil, about 1½ feet long when relaxed, and is known as a "saw-comrade" or "help-sawer." The spring is usually attached to a pointed iron rod which can be driven into the earth vertically or hammered more or less horizontally into the stump or bole of the tree that is being sawn. This little simple improvement is doubtless very helpful where a one-man saw is used.

Another type of saw which is bidding strongly for popular favor lacks the bow feature, but has a heavier blade and *cuts on the drawing motion* instead of when the saw is pushed away from the operator. This type of saw is also usually equipped with a "helper." [Advertisement–59–12/1/1928].

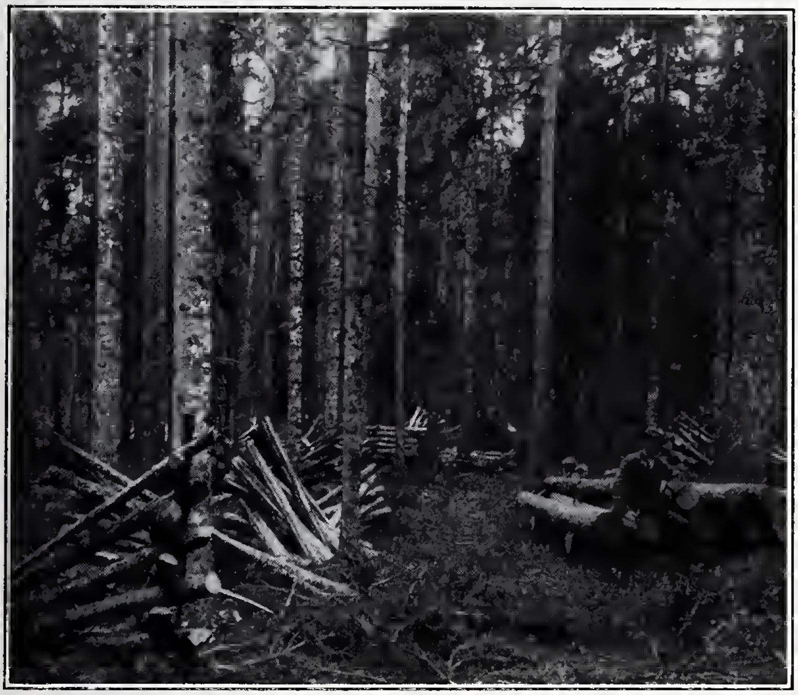

FIG. 13.—WOOD FOR CHARCOALING AND PULP BEING AIR-DRIED IN THE FOREST.

Pulpwood and logs are barked as a rule while coal-wood is not. Such mixt pine and spruce stands as here seen are very important in Swedish forestry.

All skidding is by use of a single horse, or else by man-power, except in the far north where reindeer are occasionally used. Hauling is also a one-horse job, as a rule. In the few rare instances where terrain makes it absolutely necessary that two horses be hooked to a sled, they are always driven tandem. That is very advantageous, as it permits the use of somewhat narrower style sleds than prevail in America, and then, too, a horse is not endangered by the sharp shoe-calks of its teammate as when they are hooked abreast on narrow, icy roads. Sweden can always count on plenty of snow for sledding in the forests, yet the fall is not excessive.—" Little and often " is the weather motto as regards precipitation in general there. The steady cold, with practically complete absence of sun, makes maintenance of sled roads inexpensive. Caterpillar tractors drawing trains of sleds are beginning to be used in restricted localities. Higher labor wages and cheaper motor fuel would soon force a quite general adoption of such transportation methods, as the tractor has proven efficient under the conditions at hand.

Visitors to Swedish forests in winter never fail to acquire deep respect for the shaggy-haired and rather small horses in general use. They live under very adverse conditions and subsist upon a quantity of hay and oats that is surprisingly small, yet they move loads that look amazingly large at a good brisk pace. Especially in charcoal hauling do these horses make an impressive showing. The material is light and has usually been kept carefully dry. It is hauled on sleds with large, boat-like beds which are heaped with the black coal. It is not infrequent on level or gently down-grade roads, that a single diminutive looking horse will draw as many as three of these big black loaded coal sleds hooked in train style.

LUMBER CAMPS AND LABOR QUARTERS

Because of the disagreeable features of Scandinavian weather in winter, housing is very important and so far as woods labor was concerned, a decade or so ago, the cabins and shanties used in lumbering and river driving were not attractive or satisfactory human abodes. For ease of heating they were built very low and nearly air-tight with often no windows, since it was often stated in the North that there were only two or three hours of daylight anyhow, during the winter season when these cabins were used most; while in the light summer, men preferred to eat and sit outside and generally only used the cabins to sleep in and do a minimum of cooking. This specious reasoning, however, failed to satisfy the Social Democratic governments that controlled the national legislature from time to time during the first quarter of our century, so the Social Department was instructed to inspect all buildings used for human abode, as well as stables for horses. These were required then to come up to certain minimum standards in respect to sanitation and comfort [26–218]. The ends aimed at have been largely attained through the energy and commonsense of the forester, Oscar Wallner [59–1926–165 and 311], who was put in charge of the inspection work.

The housing and domestic arrangements met in Swedish lumber camps are primitive and imperfect compared to what generally prevails in Canada and the U. S., but this century has seen great improvement and the arrangements found today are especially commendable from the standpoint of economical heating and ventilation.

TRANSPORTATION OF LOGS AND PULPWOOD

As stated heretofore, the waterways of Scandinavia are utilized almost to the limit in carrying forest products from stump to mill.

Modern trends have been very divergent when these lands are compared to the U. S. in this respect. Except in the North and for pulpwood. river driving or rafting of forest products has declined every year since the dawn of the century. The element of time and the loss of occasional logs militate against such transportation in the U. S., and rightly so in many instances, yet there is a probability that the pendulum has swung too far in this case in many localities. Running water is a steady and faithful servant of man. Northward and where small softwood material is to be moved, it would certainly be advantageous to develop and improve the water courses along such lines, as is illustrated in Sweden. The idea uppermost in stream improvement has usually been permanence. To this end it has been customary to incorporate each major stream and its branches. Practically all log-driving is in the hands of these corporations or associations, and they function just about as common-carriers. They are regulated by the government in many respects and at times directly or indirectly subsidized. As a rule, these " floating associations " (flottningsföreningar) have a dual schedule of prices, or a two-piece system of tariffs. Charges are in part based on (a) the number of pieces floated and (b) the volume of wood they contain. There are also often regulations against long pieces that might tend to form jams or otherwise cause trouble and delay during the drive [Ref.–368 to 416]. The equipment and methods of stream driving in Scandinavia exhibit great variety and ingenuity. To describe them in detail would fill a volume in itself.

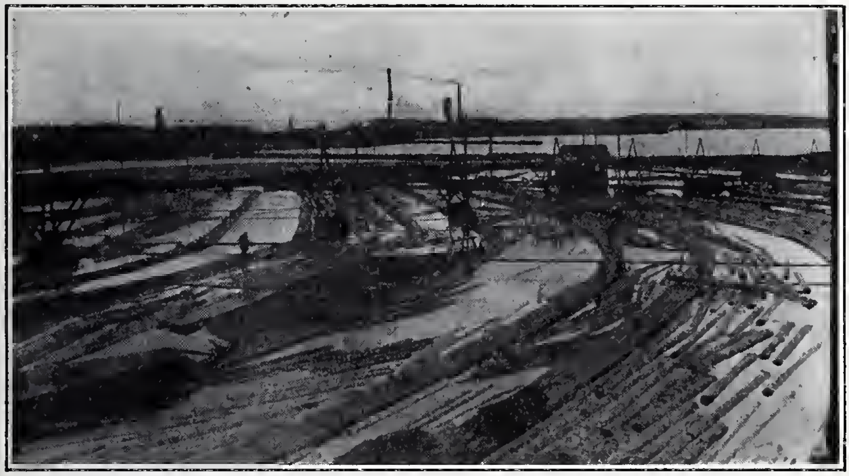

Fig. 14.—Sorting Basin and Booms Where Logs Are Separated and Headed Toward the Mills of Their Several Owners.

One of the recent developments in Swedish stream driving has been the bundling and wiring together of small tree boles floated in the public streams for pulpwood or charcoaling purposes [45–88]. This reduces the per-piece floating charge and obviates the need of barking, since except in a few private streams, it is generally required that all logs be barked before they are dumped into the streams and lakes. This provision is to prevent bark being lost from logs and filling up the sorting basins, ponds, and other waters of special importance to the business of log-driving. It is also maintained that the bark contains chemical compounds poisonous to fish.

The time consumed in water transportation of logs has always been a serious item in America. In Sweden it is taken as a matter of course, and occasionally two seasons must elapse before material reaches the mill. If this were in a warmer and drier climate, logs might suffer considerable deterioration from fungi and insects, since power developments on many streams may lower the water level and leave logs high and dry for weeks. Yet some trouble with bluing is about all the damage that occurs.

THE SAW-MILLING INDUSTRY

The special feature of Scandinavian sawmills is the frame gang-saw. This is not purely a Swedish development, but it has been greatly improved by the mentally keen mechanics and engineers engaged in the industry and manufacture of mill machinery. This general statement is also true of pulpwood and paper mill equipment. In the nineteenth century most of this was imported from Central Europe, England or America. More recently Sweden has begun to export many items to these countries, as is true to a less extent of Norway, also. Their high quality steel and careful workmanship, along with improvements, have won Sweden and Norway a place of importance in regard to machinery used in wood utilization. The Swedish gang-saw is very speedy in comparison to the gang-saws generally found in Central Europe and France. In Germany it is literally true that a log will be started into the gang and then the operator will go away to eat lunch or dinner, and get back amply soon enough to take away the boards or planks when the log is through.

The small thin blades of the Swedish gang-saw are quickly and easily adjusted or replaced. This means they can readily be kept in uniformly good cutting condition, which is always an important factor in gang-saw operations [Ref.–451]. The thinness of the blades is an item that becomes highly important in cutting up the relatively small logs that are characteristic of Sweden. The blades may be as thin as one millimeter (.04 inch) and cut a kerf of less than one-sixteenth inch, which illustrates their great economy over the wide-cutting circular and band saws commonly used in America. These latter are found in Scandinavian mills also, but are restricted in use to splitting, trimming and edging. Thin band-blades do most of the splitting and the wider cutting circular saws cannot cause much loss in other work.

The crook-saw improvement, now commonly seen in Swedish mills [45–145], is an ingenious device whereby logs that crook in but a single plane, as is usually true of conifers, can be sawn just as efficiently into good boards as can a perfectly straight tree. This end is attained by the simple expedient of shifting one or both ends of the log while it is passing thru the gang-frame in such a way that it is always kept properly centered. Of course, to begin with, the log is laid on the carriage in such wise that its maximum plane of curvature lies horizontal. Thick planks cut in this way naturally show at first some of the original curve of the log, but after they are piled under heavy weight of overlying material for drying, or probably split into inch-thick stock, the crooks can no longer be detected at all. In this way it becomes an actuality that " straight boards are cut from crooked logs " without any more loss than would occur in sawing straight timber.

The only valid objection to the Swedish gang-saw on part of the American lumberman is the fact that its adoption would require reorganization of their mills and that the saw is poorly suited to big logs, also to logs of irregular size. These are all very true and weighty objections where an operation is cutting virgin growth. In utilizing second growth and as years pass, it will be more and more desirable that the economical gang-saw of Scandinavian type replace wide-cutting bands and wobbly circular saws, such as now waste much of the best wood in our logs.

In Sweden, probably the most efficient sawmills have six gang-saws; three for each of their two " Jack ladders " that elevate the logs from the pond. One of the three gangs is practically always a " crook-saw." The saws are variable in size and the logs are sorted somewhat. In fact, the smaller logs usually go to one jack ladder with its complement of saws, while larger ones go to the other whose gang-frames are bigger and better adapted to handle them [Ref.–447].

Mills in Scandinavia are usually just as completely mechanized as in America. Live rolls and motors, levers and swinging or drop saws economize greatly as to expenditure of human energy. In the yards of larger mills, lumber is elevated to the piles by motor-driven machinery. In general, too, it can be said for Sweden and Finland that mill yards are much neater and better kept than is the average in the U. S. Each pile is put up with mathematical exactness, all ends just precisely coincide with the edges of the pieces above and below them. The roof over each pile is well made and projects amply beyond the pile on all sides. Many yards are so carefully planned and laid out, that drainage channels have been dug where necessary to carry away the cool, humid and heavy air that settles down thru the piles of drying lumber. Air drying is the usual rule, but kilns fashioned from U. S. experience are occasionally met.

All the really big and efficient operations in Scandinavia are on deep water, usually at the mouth of some considerable stream which brings down their supply of raw material. Mill yards are just adjacent to the docks and shipping sheds, where ocean-going vessels of every type can load without the expense of barges or lighters, and regardless of weather conditions, unless they be very extreme.

An arrangement very commonly seen and very useful to Swedish sawmills is the timber hoist [Ref.–434]. This permits the mechanical raising of logs from the water and storage on land in huge roll-ways until such time as they are needed.

PULP AND PAPER MILLS

During the present century Scandinavia has made rapid strides in the manufacture of paper and the cellulose preliminary thereto. Only Canada exceeds these North European lands in this field. Good raw material with abundant water and water power have given Sweden and Norway very real advantages. Finland is also forging rapidly to the fore. Of course, Denmark is practically without any semblance of water power, and hence entirely lacks pulp-mills.

The high quality cellulose from Swedish spruce has been in especially good demand since artificial silk has come in vogue for so many uses. The prosperity of this industry has been one of the economic mainstays of Scandinavia since the World War, and has been a special blessing to the forest owner in a trying crisis of adjustment and prevalent low prices for most forest products.

Swedish mills have little to offer America in the way of suggested improvements, except as regards a few features:

(1) Coördination with other wood-using operations as a means to better silviculture. Almost no pulp-mills stand alone as independent projects. For the most part they are associated with sawmills and also with iron and steel manufacture in a few instances. The American idea of pulp operation, taking the total yield from vast areas of virgin forest, seems very ineconomic to the Swedish mind. This industry is to some extent a scavenger, using all sorts of waste and inferior material from rotten log butts and top wood to sawdust. It also uses an increasing quantity of small stuff removed from the forest as thinnings and in improvement work.

(2) Mill machinery is being constantly studied and improved. The average Scandinavian mill today wastes less and is more economically arranged and operated than is the case with American mills. For example, I am told that chippers in Swedish sulphate mills now cut chips of remarkably uniform and exactly the desired size. Our chippers waste much by grinding out a quantity of fine stuff that is lost.

(3) Mill storage yards are models of good order. Loss of wood and deterioration in quality of product, because of wood decaying in the yard, is practically unknown in Sweden. The mill yard boss can always tell within a few days just how long each piece of wood has been in storage.

(4) By-products and waste chemical recovery is somewhat more efficient in Sweden than in the U. S., altho we are making commendable progress along this line. In only too many instances, however, our mills are killing fish and ruining the recreational possibilities of splendid streams by discarding waste liquors and short fibre stock which the Swedes have learned to recover and use at a profit. The

smell is now literally all that escapes from many Swedish mills, and even this is being reduced to an innocuous quantity and character [Ref.–571].

In sulphate manufacture of pulp in Sweden a considerable yield of turpentine and wood alcohol is secured, as set forth in Table XCIV. When the wood of pine is cooked with an alkali, the oils and resins form a soap which is separated and recovered when the cooking liquors are concentrated. This soap is usually broken down by cooking with sodium bisulphate, whereby resins and fatty acids are liberated and recovered under the commercial name of "volatile resins" (*flytande harts*) and find a ready market as raw material for manufacture of laundry and toilet soaps, as well as many other uses.

TABLE XCIV.—By-products from Manufacture of Cellulose

Name of Product	per Ton Pine Cellulose	per Ton Spruce
Oil of Turpentine	17.6 lbs.	4.4 lbs.
Methyl Alcohol	11.0 lbs.	11.0 lbs.
Volatile Resins	44–55 lbs.	a small quantity

In sulphite manufacture wood alcohol is formed just as in the sulphate method. Part of it goes off in the gases from cooking and part remains in the offal liquors. Some Swedish mills recover alcohol from the gases. In this method, also, about 8% of the wood is converted by cooking into fermentable sugars. The Swedes originated a method whereby this sugar is recovered and finally appears as ethyl (grain) alcohol. The waste liquors are neutralized with lime or ground limestone, cooled to a suitable temperature (about 95° Fahr.) and then fermented in huge tanks of concrete or wood. The liquor yields about a 1% solution of alcohol, which is recovered by ordinary distillation. The quantity secured varies from 36 to 55 quarts of 95% grain alcohol per ton of cellulose. The yield would be much greater if all the waste liquors were recoverable, since from 30% to 40% is retained in the cellulose and washed away in later purifying processes.

In the sulphate method, the Swedes have been recovering and using as fuel the remainder of the 50% to 60% of wood mass which does not appear in the finished cellulose.

In the sulphite method there is a loss of 40% to 50% of the wood which has interested the chemists of the world for a long time.

The Swedes are working on certain promising lines in this connection, whereby the wood and organic matter is precipitated from the waste liquors by forcing certain gases thru them. The precipitated material can then be used as fuel or it may prove valuable as the source of raw materials for a wholly new chemical industry. In this connection, it should also be stated that Sweden possesses in Peter Klason the most famous and boldest wood chemist in the world [62–385, 63–419 and Ref.–157].

THE CHARCOAL INDUSTRY [Ref.–598]

Incidentally this phase of forest production has been frequently referred to in foregoing chapters. Absence of coal deposits in Sweden and Norway have necessitated that the iron and steel for which these lands are justly famed must all be produced with charcoal. This has usually meant a somewhat more expensive product than might be made by using coke, but the quality is the best in the world. Special reasons exist to make the above statement true. One of these is the fact that in Central Sweden there are considerable iron ore deposits of very low phosphorus content. This excellent raw material is treated with special care to eliminate all contamination in manufacture. For example, in the matter of phosphorus,—no birch or other hardwood is permitted to be charcoaled, since they retain when cooled more than four times as much of this element as do pine and spruce. The conifers are nearly always barked before coaling because the bark contains ten to fifteen times as much phosphorus as is found in the wood, altho this is very little. Sapwood of these conifers holds four or five times as much phosphorus as their heartwood, but it can be leached out to a considerable extent if the wood is floated in water for some weeks. This fact is also taken advantage of by the iron industry, as they have a considerable number of ovens or special places to which water transportation gives the desired advantage. Then, too, coaling of slabs and waste from mills is encouraged, since this material (*ribbved*) is all well leached out while the logs are being driven [Ref.–615] to the mill.

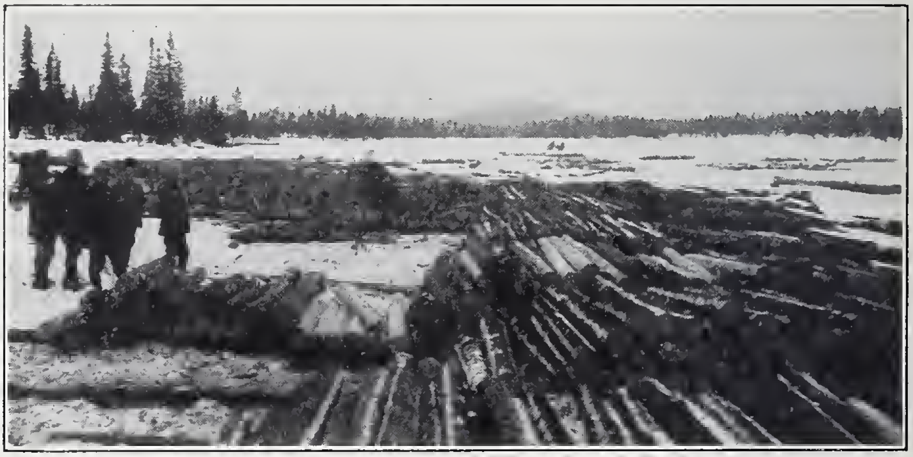

Fig. 15.—Logs in North-central Sweden Piled for the Spring Drive.
The small logs seen here are characteristic. In this instance they are rolled up onto skidways on a frozen bog which will be converted into a lake in spring by construction of a splash-dam.

Most of the charcoal produced, however, is coaled in the woods just about as was formerly the prevalent custom in many localities of the eastern U. S. Two general types of coal-pits are met,—(1)

one is built round-conical with the pieces of wood standing more or less upright, as was the usual method in America (*resmila*); while (2) the other (*liggmila*) consists of piling the pieces horizontally, sort of skidway fashion, and so ordered as to transmit the fire from one end, where it is kindled, to the other. Pits are very carefully covered in Sweden. Spruce boughs and sphagnum moss make the first layer. Fine charcoal braize and woods earth make the outer layers.

Charcoaling proceeds in the woods all thru the late summer and early winter at its best. Even in spring some coaling may be done, so it is practically an all-year-around job in favorable localities. The winter season of good sledding is the time when the product is brought out to the railroads and navigable waters for transportation to market. Until that season arrives, the coal is usually stored up in crude coal huts made of logs, thatched with spruce boughs or peat. As a rule, the coal is carefully screened in the forest and all pieces not sufficiently charred are carefully reserved for a special place in the succeeding pits to be burnt in the locality. The importance of charcoaling to good silviculture in Sweden is only surpassed by the pulp and paper industry.

Swedish engineers are reputed to have perfected a quite efficient motor that uses finely pulverized charcoal as fuel. If such an invention equals the dreams of its well-wishers, and coke is not found a substitute for charcoal, it will assuredly revolutionize silviculture.

FUEL FOR A NATION

Devoid of coal, Scandinavia needs wood for fuel in vast quantity. Finland is the outstanding "Wood for fuel" country of the world. Not only does she ship each year many boat-loads of birch wood to Sweden, but by law the railroads are compelled to use wood fuel, and the large ranks of prime birch stacked to dry in the railroad station wood-yards are an ineffaceable recollection of that country.

The general use of wood as fuel in a city of upward near a half million population, built in general on the plan of five- to eight-story apartment houses, is most interesting. The writer carefully investigated the wood consumption and was quite amazed at its efficient organization in Stockholm.

The wood is brought into the city by water or rail and unloaded in the shape of cordwood at probably a half-dozen places. Some of it is brought in by retail fuel dealers, but for the most part wholesale operators stack it up in frames of a given size as they unload it and sell, after inspection, to the retail dealers. These men saw the wood into lengths of about a foot or possibly less, then split it up into pieces of about five square inches cross section. Electrically-driven wood-splitters are in common use. The wood is then packed into bags that hold about four to five cubic feet. In these burlap sacks it arrives in the apartments where it is to be burnt.

Very few houses in Stockholm have a central heating plant, but instead all tenants heat their own rooms. Gas is sometimes used, but it rates as a luxury of the rich. Coal and coke are only used by the better-to-do classes, or in bitterly cold weather, when they may supplement the use of wood. Heating is generally by means of a *kakelugn,* or huge closed fireplace of glazed tile lined with firebrick. These formidable-looking ovens stand solemnly in the corner of nearly every room and are either circular, square, or triangular in cross section. They are usually eight to ten feet high and variable in size from three to five feet diameter, or its equivalent. These huge ovens can be shut up quite nearly airtight, and it is the custom in ordinary weather to build a good hot fire in them at a given time in the day, and after they have been well warmed up, a little more fuel is added and all drafts are shut so the heat is carefully retained and slowly radiated into the room for the next twenty hours or longer. All rooms are also very tightly built, so it is a wonder more accidental deaths from smothering and gas effects are not recorded. Nearly all windows and doors are double, and in the autumn it is the custom of the country to buy gummed strips of heavy paper, which are carefully pasted over all cracks where window sash join and there might be some possibility of a breath of air entering the house. Sealing up the windows for winter is almost a religious rite with good Swedish housewives.

TABLE XCV.—WOOD USED IN REGIONS OF DIFFERENT WINTER TEMPERATURES ON FARMS OF VARIOUS SIZES

Areas of Land Cultivated per Farm (acres)	Average Temperatures, Oct. to Apr. Inclusive				
	Under 28.4° F. (cu. ft.)	28.4$_0$ to 30.0° F. (cu. ft.)	30.2° to 32° F. (cu. ft.)	32° to 33.8° F. (cu. ft.)	Over 33.8° F. (cu. ft.)
.6 to 2.5	669	557	486	482	375
2.5 to 5.	1506	605	536	433	365
5. to 7.5	1008	666	553	518	314
7.5 to 12.4	1136	798	547	528	461

A number of statistical studies on fuel consumption are available and ample data of a general nature in this connection have been given in Chapter III. It must be stated, however, that the farms are heaviest consumers of wood, and this varies rather widely in keeping with the climatic character of the locality and the size of the households or areas of woodland available as a source of supply. Farmers generally are not so parsimonious in the matter of fuel as are their city cousins. Table XCV shows the effect of climate on the total consumption of wood in Sweden [52–50].

In comment on Table XCV, it may be said that the variations set forth are in line with a universal law that is very logical. In the U. S., fuel consumption between Maine or Ontario on one hand, and Mississippi or Florida on the other, shows a wide variation which must always have a noticeable bearing upon local silviculture and the attitude of the people toward the forest.

THE FOREST AS AN ÆSTHETIC RESOURCE

In Northwest Europe, just as in Germany, the Christmas tree is specific and definite. In Central Europe, it is the fir tree (*Tannenbaum*), while in Sweden the term Christmas or Yule spruce (*Julgran*) is always used. Nearly every family must have its spruce. The holiday season is a period of universal relaxation, when old and young follow their impulses in a way unknown to New World peoples. The forest is called upon to supply, in a large measure, the decorations for public and private places. Whole streets in Stockholm are commonly festooned with closely-hung ropes of woven spruce and pine twigs. All thru the long dark winter nearly every Swedish living-room has its vases filled with fresh cut evergreen boughs, or branches of birch and alder are brought in and forced to put out prematurely their tender and bright green foliage and catkins, as a sort of prophecy foretelling the general resurrection of nature when winter, with its cold hand of death, is finally conquered by the rising power of the life-giving sun.

Spruce boughs are also cut and used in rural places for door-mats. The fresh cut boughs for this purpose must be renewed every week or so. They give an artistic touch to an everyday commonplace item in a way which is very typical of all Northwest Europe.

The narrow homes of the dead are not forgotten in winter at the season of holiday happiness. This is Decoration Day time in Sweden. The country spends each year literally millions of dollars for warm greenery to clothe the graves of loved ones departed. Cemeteries are really art museums each winter, so far as the skill, taste and ingenuity of florists and sorrowing relatives go. The raw materials for this decorative tribute, to the extent of 90%, come from the forest.

In some localities, such as the environs of Stockholm, where law enforcement is lax because the lands are primarily valuable as future building sites, collection of greenery from the forest has been quite detrimental, but in general the regulated marketing of this decorative material, where it is taken out as thinnings or in course of usual operations as a by-product, the income is most welcome and desirable. From an æsthetic, social, and economic standpoint, it is to be hoped that we may develop such customs as here described, since thereby mankind comes intuitively to an appreciation of the forest as a pleasant and beautiful associate, benefactor, protector and friend of our race.

WOOD USING INDUSTRIES

Less so than in America are wood substitutes met in Sweden. Industries based on wood are very well developed. Many of them use imported raw materials. Wooden boxes have not yet given away to fibre board containers so completely as in the New World, in spite of the high development of paper pulp-making. Very fine furniture is made in Scandinavia. Cabinet-makers are highly trained and skilful. Veneering is well developed, using many exotic woods from

America and the tropics, as well as oak from Central Europe. For matching grain, it is very common to find thin sawn boards handled and piled carefully together, so that adjacent faces from the same log can be used in panels and will exhibit identical natural figuring.

Birch is the native wood mostly used for veneering in Scandinavia. From it very attractive furniture is made. The splendidly appointed College of Forestry is furnished thruout in this wood.

The Swedish safety match is a household article everywhere in the world. It has an obvious forest background. The match-stick wood *par excellence* is European aspen. The boxes are made of birch veneer, as a rule. The organization of this business is very modern and effective, with the best possible manufacturing and merchandising technique.

Railroad ties and poles are lines in Sweden that call for considerable wood of good character. Pine has been most used in the past, but larch is preferred for both uses. Untreated pine would be quite unsatisfactory, under warmer climatic conditions, but in Central and South Sweden decay is very slow, due to the low prevailing average temperatures along with excessive humidity most of the time [63]. Preservative treatment of wood used under exposed conditions is becoming very prevalent [Ref.–916]. The government is the great user of poles and railroad ties, and has initiated a very elaborate series of experiments with almost every known substance likely to be effective toward prolonging the life of wood.

Many of the splendid apartments in Stockholm are built on wooden piles where almost bottomless marshes once existed. In fact, the whole area thereabouts alternated between fjords that tended to become bogs on one hand, and solid glaciated granite cliffs and ridges on the other. Piles used under buildings in recent years have often been of reinforced concrete. These are tipped with an iron point and are more easily driven than is the case with wooden piles.

In compiling the foregoing pages, the author has gradually come to sense the fact that it is impossible to write a complete story of forestry in Sweden and adjacent lands, for the simple reason that the science and practice there are in a state of progression. It is also always possible to go deeper into detail and unearth facts of interest. Facts recorded here are set forth in the light of the impression they made upon the writer and often by contrast with corresponding American conditions. With regrets for any possible errors, and a wish that some statements herein may militate toward international understanding and the development of better forestry in all lands concerned, this chronicle will not conclude, but merely cease, until probably, in course of time, someone better equipped may take up the recital.

THE END.

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